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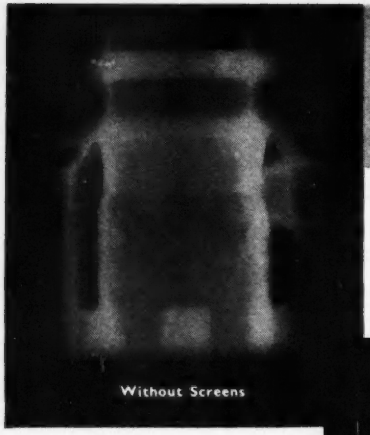

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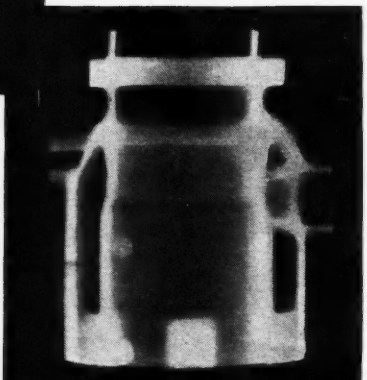

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# The Progress of Science

A MONTHLY NOTEBOOK COMPILED UNDER THE DIRECTION OF DAVID S. EVANS

## The Technician in the Laboratory

MANY scientists are extremely good at all kinds of manual work. This applies most, of course, to the practical experimental or observational scientists, but one recalls that an eminent pure mathematician, who owed his fame to the proof of certain mathematical formulæ conjectured by the self-taught intuitive Indian mathematical genius, Ramanujan, was an expert knitter. The good laboratory worker can usually do all the domestic maintenance jobs like fixing electrical equipment, putting washers on taps, relaying loose floor-blocks and even, in these days, repairing shoes—if he has time. A curiously similar situation prevails even in some laboratories. The scientist can usually make a fair job of a bit of elementary lathe-work, is often quite a good fitter or glass blower, can get along with sheet metal work, repair his own instruments, make his own slides, and even turn his hand to a bit of optical glass work. Naturally it is rare to find one man who can combine even a moderate level of attainment at these tasks with capacity for his own special work of research. If necessary he can get along by his own efforts in these practical fields, and he may find himself during the course of a day using the tools of half a dozen different trades with some measure of skill. It is often a pleasure to do these jobs, and there is a certain pride to be felt in the ability to be a Jack of all trades, but the bald fact remains that the Jack of all trades is rarely the master of many. If the scientist is to make headway with his own proper work in the laboratory, he cannot spare the time to do all these other tasks.

In this connection we cannot do better than quote the remarks of Dr. David Shoenberg in his essay "Physical Research in the Soviet Union" which forms one of a collection published under the title of *Science in Soviet Russia* (Watts, 1942). There he says, in discussing the question of laboratory assistant staff, "All this technical help made for much more efficient scientific work; instead of wasting time, as is so often necessary here, in painfully making a sealing-wax-and-string job of some apparatus, I had merely to discuss the matter with the head of the appropriate department, put in a chit for it, and get the job done competently and reasonably quickly by experts. The electrical fitters I also found very useful, for at short notice they would do any wiring up for an experiment much more neatly and quickly than I could manage myself. These features allowed the scientific workers to concentrate on their real job, the planning, execution and interpretation of scientific experiments, without wasting too much of their time on jobs at which they were amateurs".

There is nothing specifically Russian about this experience. In the best laboratories here the same collaboration between the scientist and the specialist in laboratory arts exists. There may however be general truth in what Dr. Shoenberg notes in his comparison between the Royal Society Mond laboratory in Cambridge and the Institute of Physical Problems in Moscow; he found that, whereas in Cambridge there was only one other employee for each scientist, in Moscow there were ten.

It is the role of the laboratory assistant to provide specialised skill in a particular department of laboratory arts, and thereby to extend the field of competence of the team comprising scientist plus assistants beyond the bounds of that covered by the scientist alone. There have in the history of science been many assistants who were positive geniuses at their own special skill and who contributed an essential part to the progress of the whole investigation. We have now become accustomed to thinking in terms of research teams and we owe it to this particular class of laboratory worker to recognise the part which he plays, and to give credit where it is due by including his name when research results are published. This may present certain difficulties, especially that arising from the printing of a plethora of names beneath the title of a paper. However, this difficulty ought not to be too great to be surmounted, and the possibility might even be considered of publishing the results of team research under some "trade name" while including at the end of the work a list of the team playing on this occasion. This

The Ministry of Supply's Chemical Inspection Department has a school where 750 pupils, mostly girls, have been trained during the war up to the "chemical assistant" level. Many of the trainees have gone to the Inspection Department's out-stations, others have become assistants in Government Research departments and R.O.Fs. After the war there should be a valuable reserve of laboratory technicians for schools, universities and industrial establishments.

proposal may seem a little unusual but it would be a step towards removing the popularly held fallacy that each discovery must have had a single discoverer.

This, however, is a minor point beside the general problem of raising the standard of the laboratory assistant's profession. Many of them enter it on leaving school at an age of sixteen or so. They receive comparatively low wages, although a good assistant is often capable after a couple of years of doing highly intricate work. More serious is the fact that the junior assistants are more numerous than the senior ones. For a considerable proportion of junior workers the job must inevitably be a dead end, and they are compelled at the age of twenty or so to seek work in other capacities.

The second difficulty concerns the educational opportunities of laboratory assistants. It is now fairly common practice, although regrettably not a universal one, to allow assistants in their early years to have time off for attendance at local technical schools. This forms part of the solution of the problem for it does leave the young worker with some time and energy to spare for his further education, and usually offers him a qualification of some kind which will help him to gain employment in another laboratory.

Supplementary to this, however, should be the opportunity of becoming a fully qualified scientist if he so desires. Here it must be recognised that a considerable proportion of laboratory assistants are by aptitude and inclination quite unfitted for original research, and that many of them would be satisfied if their chosen employment afforded them the hope of a status and salary appropriate to the superb level of skill and initiative which is demanded from the occupant of such a responsible post as the head of the workshop in a large scientific institution. There are however, assistants who have all the qualifications for full scientific research and who have through lack of opportunity been unable to enter the profession. Even now cases are known where an able young man or woman has succeeded, through spare-time study, in gaining a degree and securing employment as a fully-qualified scientist, but all too often what is still thought of as a "lowly origin" proves a handicap in the later stages of such a career, and produces in the scientist who began as an assistant either an exaggerated defensiveness or a serious lack of self-confidence.

We must admit that the assistant is an essential worker in the scientific effort and that he does a job, which is often both highly diversified and highly specialised, better than the trained scientist could do it himself. We must also recognise that the general assessment of the result of twenty years of this work is usually in terms of a salary about the same as that secured by a graduate in his first job, when all he has to show besides a good theoretical knowledge is the most superficial acquaintance with practical work.

There is a very strong case both for improving the status of the laboratory assistant financially and making it a career which anyone—even a graduate with the necessary ability—might be glad to follow. At the moment the rewards are such that, however unsuitable he may be for scientific work proper, there is an inducement for the assistant to attempt to gain academic qualifications, and to withdraw from a sector of work where he might be far more useful.

Many of these problems would be solved if we had in this country a training institute for laboratory assistants of the calibre of the Leyden school, which, in association with the neighbouring institute for low-temperature research, produced workers who could command employment anywhere in the world. If such an institute were set up here, it would benefit British science by providing assistants of a recognised standard who would be able to take up the highest grades of work at once. At the same time, the existence of such a standard of qualification would make the profession attractive to men of the high attainments which are required, and make it easier for them to gain the recognition which they deserve. The efforts of the Institute of Physics in providing diplomas in laboratory arts and of the Pathological and Bacteriological Assistants' Association in setting up suitable standards of qualification must be acknowledged here but, even so, the lack of a definite teaching institute providing full-time courses still leaves a serious gap to be filled.

## Future of British Television

INTEREST in this subject has been demonstrated by discussion meetings at the Institution of Electrical Engineers and at the British Institution of Radio Engineers, as well as by many articles in the technical press and the

daily press. Britain was the first country to establish a regular public television service, and the time has now come to decide whether the system established in 1936 is good enough to continue in 1946, or whether we should take advantage of the interruption of the service caused by the present war as and make full use of our opportunity to replace it by a better system.

The various proposals for post-war television can be reduced to three main possibilities. The first is simply to recommence the pre-war service, which had a definition of 405 lines per picture. This would give the quickest possible start after the war, and would allow the pre-war television receivers to be put into service again. But that would fail to raise our transmissions to the standards adopted by later entrants like the U.S.A. which has a definition of 525 lines per picture. There is talk of gradually making improvements later, but the continued increase in the number of receivers in use and the number of transmitters (for it is agreed that the television service must be extended to other areas outside London) would make change progressively more difficult.

The second proposal is to take as long a step forward as is consistent with manufacturing television receivers at a reasonable price and as quickly after the war as the transmitters can be built. This means adopting something like the U.S.A. standard, 500 to 600 lines per picture, and carrier frequencies around, say, 55 Mc/s. instead of the pre-war 45 Mc/s. It involves no technical difficulties, and therefore no manufacturing delays, and represents sufficient improvement over the pre-war system to allow it to be accepted as permanent for some years. The next stage to be taken, after perhaps ten years, would be a system including colour and picture definition equal to that of the cinema, to be introduced in addition to the existing system. The latter would still continue long enough to give a fair working life for the equipment already in use when the new system commences.

The third proposal is to jump directly to a super-definition system of the type which the second proposal would introduce as a second service at a much later date. Nearly everyone agrees that this would entail considerable delay before equipment could be manufactured, and result in much higher receiver cost than either of the other proposals.

The Government has set up a Television Committee under the chairmanship of Lord Hankey to examine the technical problems of post-war television, and the Committee's report will show how far Britain can hope to retain technical leadership in television and at the same time produce receivers at a reasonable price.

## University of the Air

"NEVER was so much owed by so many to so few," said Mr. Churchill of the Battle of Britain. It was a battle won by a small, highly trained and superbly brave air force flying the best fighter which the world then knew. The R.A.F. won that battle—but suffered decimation in the process. We remember the glory of that vital victory: we ought also to remember the narrowness of the margin by which it was won, and the price which it cost. We ought not to conceal from ourselves that the production of the Spitfire would have been impossible had it not been for what might almost be described as a lucky accident—Mitchell was fortunate enough to have the facilities for bringing his vision to practical realisation. There were in fact serious defects in the organisation which then existed for putting the latest developments of aeronautical knowledge at the disposal of the aircraft industry and the R.A.F., and it was a matter of good fortune rather than good management that the existence of these defects did not cost us even more dearly than they did.

The recent report, entitled *A College of Aeronautics* (Stationery Office, 1944; price 2*s*.) and prepared by an interdepartmental committee set up by the Minister of Aircraft Production, is thus an extremely important sign, not only in its own field, but for the light it sheds on the general problem of the relation between science and industry. There is a frank recognition that enough high-grade science has not been integrated into the fabric of aeronautical affairs as a whole. The operative word is *integrated*. First-rate scientific knowledge must permeate the whole structure and affect the outlook of all personnel concerned. It must not simply be grafted on at the top.

The primary object of the college is to train a *corps d'élite* of applied aeronautical experts who will eventually spread the gospel in the industry and the Service. To this end the provision is recommended of a two-year course for an annual entry of 50 students at the post-graduate stage. In addition there will be, at any one time, provision for 200 students on short refresher courses in particular subjects. There will be a large, highly qualified staff, with one staff member to each six students. Research both for industry and the Services, will be pushed ahead. The institution will have its own airfields and, it is hoped, entirely new and specially designed buildings. It will, altogether, have some 60 aircraft for instruction and for experimental flying.

The details of the proposed college have already been fully published in the Press, and it seems hardly necessary to repeat them. There are, however, one or two very significant features about this report which are worthy of comment. First, the college will not be associated with any university unless, at a later date, this should seem to be desirable. This appears eminently sound. Here is a new kind of place which must develop its own traditions, and which would be quite likely to suffer if it felt obliged to mould itself to the tradition of some older body. Secondly, the college is going to be properly equipped; the list of equipment which is given is so complete as to make any university laboratory green with envy. There are for example to be a dozen wind tunnels, while such items as "Electron Microscope" are thrown in almost in passing. The scale of equipment is lavish only by comparison; it is probably the minimum which will be needed for proper working. If the College were attached to one of the existing universities there would be an almost overwhelming temptation to secure the use of part of this equipment for general university purposes, which would naturally interfere with the effectiveness of the college. On the other hand it is to be hoped that, even at a distance, the standard of equipment will prove an inducement to imitation on the part of existing scientific departments.

The only point of criticism which one can find is that the proposal to make all entrants scholarship-maintained, a point which was included in the report made in 1943 by

the Aeronautical Research Committee, has been replaced in the interdepartmental committee's report by a recommendation that part fees should be charged. It would indeed be tragic if any of the effectiveness of the college were to be destroyed by the inability of students to attend because of financial difficulties.

This report will undoubtedly be welcomed generally. It is widely realised that, as the report states, the establishment of the college is a matter of urgency. This implies no criticism of the efforts of the aircraft industry as at present constituted, or of existing research establishments. It merely means that existing arrangements have not been effective enough in raising scientific and technical standards throughout the field of aeronautics, and that this new agency must be created to supplement them.

## The Versatile Plate

THE photographic plate is one of the most flexible instruments of scientific investigation ever developed. Its simplest use is in making a permanent record of a distribution of light and shade in an image produced by a lens, or in a simpler language it can be used for taking pictures of people, scenes, apparatus, natural phenomena and so on. Its power of rapid recording has been developed to such an extent that suitable plates and cameras can catch the details of movements requiring only a few millionths of a second for their execution.

Its flexibility has been developed in another way too. The earliest photographic plates were completely insensitive to red light and recorded light of only a very limited range of colour. Thus an ordinary photograph of the girl friend dressed in brilliant red and black costume would show her attired in a uniform black, the red light reflected from the red fabric having completely failed to register. However, later developments have extended the range of sensitivity of photographic emulsions until now plates and films are obtainable which are sensitive to any part of the spectrum from short X-rays up to the infra-red.

Yet a third development has been in the increase of resolving power or capacity for exhibiting detail. Enlargements of hundreds of diameters are now possible with certain emulsions without loss of definition. The reason why there is a limit to the resolving power lies partly in the limitations of the optical system used to form the image, and partly in the fact that the image on a photograph is built up of a very large number of tiny silver grains each of which has undergone a chemical change under the action of the light. Unfortunately for some reason there seems to be a connection between the size of grain and the speed of the plate, so that fast plates have usually been less perfect in definition, that is they have comparatively large grains, as compared with slower plates. However, much effort has been expended on the problem of securing both a small grain size and high speed, and emulsions are now available in which very high speed is combined with only moderate grain size.

The ideal photographic plate—never likely to be attained—would thus be one which was equally sensitive to all regions of the spectrum, and which had a high speed and very minute grains.

Now one of the most fundamental operations of science is the measurement of the intensity of light. It is needed in all sorts of studies in illumination, and even more commonly in what is called spectrophotometry. Here the light from a source is spread out into a spectrum, that is, the various constituent colours in the light are separated from each other by a prism or other means. Spectrophotometry is used in all sorts of applications, of which two examples will suffice. One is the measurement of the amount of light of different colours which is transmitted by biological solutions of various kinds. This is important because from a knowledge of the way in which a particular solution absorbs light of various colours much can be deduced about the structure of the molecule responsible for the absorption.

Again, in physics, hot gases of various elements and compounds produce characteristic spectrum lines which enable the elements and compounds to be identified. For example, heated sodium vapour, produced perhaps by dropping common salt into a flame, emits a light concentrated into two wavelengths in the yellow part of the spectrum. Alternatively, if white light is shone through an enclosure containing sodium vapour the same two wavelengths are abstracted from the light in its passage through the sodium, producing a darkening at the same two

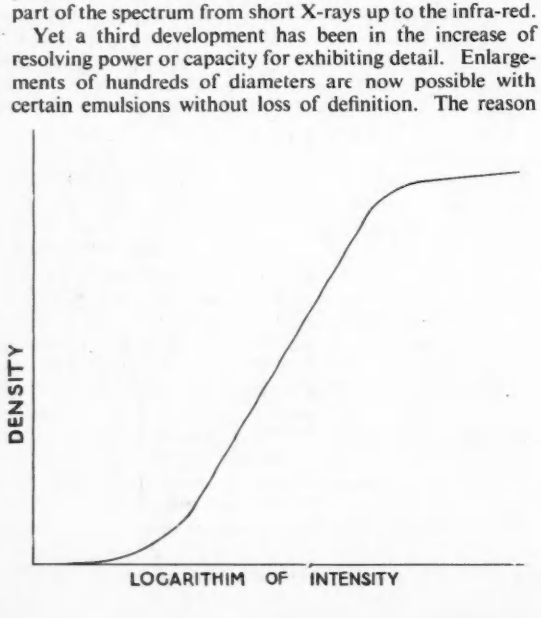


FIG. 1 (left).

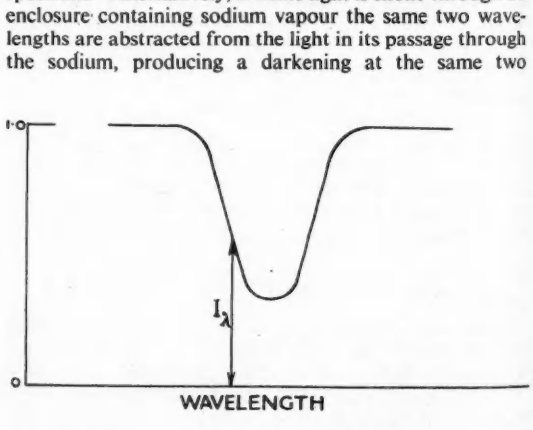


FIG. 2 (above)—Method of specifying intensity in a spectrum. The intensity $I_\lambda$ at wavelength $\lambda$ within the spectrum is specified as a fraction of the intensity outside. The variation of $I_\lambda$ with $\lambda$ gives the shape or "profile" of the line.

positions in the spectrum. These so-called "lines" although very narrow and occupying a far more restricted range of wavelength than the absorptions encountered in biological work have a definite width. The intensity does not fall off with catastrophic suddenness, but has a definite variation. If this can be measured, much information can be gained about the numbers of atoms responsible and the conditions under which the atoms exist, whether it be in a flame, in an arc, or in the atmosphere of the sun or a star.

Here then is the problem. To measure these light intensities, using the photographic plate, which has the great advantage that it can record all the details of a spectrum instantaneously, leaving their later analysis to the convenience of leisure.

To accomplish this we have first to investigate the response of the plate used to each particular colour of light. The result of such an investigation is what is known as a characteristic curve, which is of the type shown in the diagram. (Fig. 1.) The vertical axis measures the density or blackening, the horizontal axis the intensity of the light responsible. We do not plot the intensity directly but its logarithm, so that if, for the sake of argument, a step of one-inch along this axis means a doubling of the intensity, a two-inch step means a further doubling, and so on. Such a characteristic curve refers to the same plate under the same conditions of development and exposure. If we kept the intensity constant and varied the exposure time, we should obtain a similar curve relating density to the logarithm of the exposure time.

The shape of the curve illustrates several points familiar to the amateur photographer. A certain definite intensity is necessary before any image is recorded at all. Thus an under-exposed picture cannot be made to show up all the details, however long it is developed. If the picture is over-exposed, all the features will be blackened at the same time, and the family group will come out looking like a concourse of negroes in an unlighted coal-cellar. A really good photograph is one in which all the densities lie on the straight part of the characteristic curve. The speed of the plate is measured by the steepness of this part of the curve. A very steep slope means that a small increase in intensity produces a large increase in the blackness or density of the image. In spectrophotometry we usually need to know the intensity of the light within the spectrum line as compared with the intensity outside (Fig. 2) so what has to be done is first to measure the density, and then to read off from the curve the logarithm of the intensity to which it corresponds. This is compared with the logarithm of the intensity corresponding to the density just outside the line. The difference of the logarithms then gives the ratio of the intensities.

Thus spectrophotometry, using the photographic plate, can be a very laborious process. First the spectrum must be obtained, then the characteristic curve of the plate must be determined—no easy matter in itself—and then the densities on the photographic plate must be measured. This last operation can be carried out by the aid of a special instrument which does the job automatically, but even then a whole series of minor calculations must be undertaken to convert the densities into the intensities to which they correspond.

The process can be illustrated by the sequence of

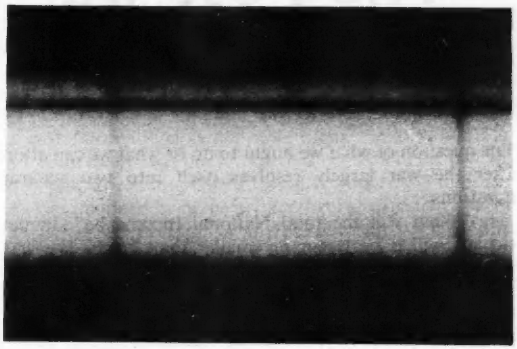

FIG. 3.

FIG. 4.

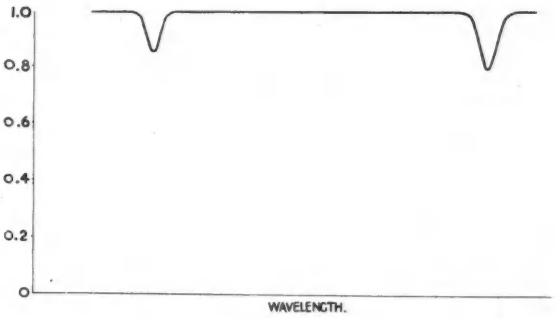


FIG. 5.

diagrams. The first (Fig. 3) shows an actual spectrum. The next (Fig. 4) a record of the densities on the plate, and finally (Fig. 5) their reduction to actual intensities. This sequence actually refers to the two lines of the sodium spectrum, and it is immediately possible to deduce the numbers of atoms responsible for them and certain other information about the conditions of formation.

This is a rough sketch of one of the fundamental techniques of modern science. It is perhaps a little humdrum, but it is a good example of the amount of work which must be done before the observations can be served up ready for discussion. The full analysis of a complicated spectrum by these methods may involve hundreds of thousands of measurements which must be completed before any theoretical work can be done at all. The final theoretical discussion which may lead to new advances in science is thus based on a tremendous mass of material, which has been accumulated not by facile brilliance or "inspiration" as the popular novel would have us believe, but by unremitting effort lasting perhaps months or even years.

# The Post-war National Income

ECONOMIC RESOURCES FOR RECONSTRUCTION

H. W. SINGER, Ph.D.

THE question of what we ought to do or what we can afford after the war largely resolves itself into two separate questions:

(a) What will the total National Income be? In particular, will it be larger or smaller than before the war?

(b) What is the order of priorities, that is to say: On what principle ought we to allocate the limited means to the various needs of social economic reconstruction?

In this article we shall be concerned with the first of these two questions.

## Shall We be Poorer after the War?

This question we ought to be able to answer from the economic analysis developed in the article on The National Income in October's DISCOVERY. There we saw that the National Income depends on four factors: (a) the national output (b) the volume of foreign trade, (c) the terms of foreign trade, (d) the income from investments abroad. What definite statements can be made on these factors?

We are on safe ground in connection with investments abroad. In the course of the war, England has liquidated a very high proportion of her investments abroad. Lease-Lend has not been made retrospective to cover the early period of the war when America was not an active participant. The Lease-Lend Agreement contains somewhat vague repayment clauses, which may or may not involve further payments after the war. In addition, England has made financial arrangements with certain countries, especially India, which have turned out to be greatly to the advantage of those countries. A certain part of the effect of these generous—or possibly improvident—arrangements has been offset by generous cancellation on the part of some Dominions, especially Canada.

All the same, a very considerable debt to the Dominions, India, and Argentine especially, has accumulated during the war, and is still increasing at a very rapid rate. It is also clear that the shift of war activities from Europe to the Far East will even speed up the accumulation of such debts, especially to India. Possibly England may be partly compensated for all these losses by a share in Japanese foreign investments or by reparation claims against the Axis countries, but this is a very doubtful offset. On balance, therefore, it will be prudent to assume that England will finish the war with foreign investments reduced to a mere fraction of their previous level or with none at all.

## Dis-investment and our Standard of Living

What will be the economic results of losing the status of a large-scale creditor? To begin with it will clearly mean an immediate loss of the £200,000,000 worth of extra imports which England could obtain without paying for them in exports and which enabled the country to raise its real income above the limits set by its national productivity. This loss is equivalent to some 4 or 5% of the pre-war flow of goods and services.

This is, however, of less importance than the precise way in which the import surplus will be reduced. The desirable way, clearly, would be to maintain imports but to increase exports sufficiently to bridge the gap. In that case, the loss in standards of living might be very small, because the productivity of labour in the export industries is high, because at least in the older industries there are unemployed resources to be taken up and also because in many British export industries, especially those in the engineering field, there obtains the law of increasing returns with a increasing scale of production. This means that an extension of total output by an expansion of exports would raise the average productivity of labour in those industries. On the other hand, it might, of course, be that the extra exports required to bridge the gap could only be sold at lower prices. In that case there would be a deterioration in the terms of trade and a further fall in the standard of living additional to the direct loss of income from investments abroad. The problems of the terms of trade and income from investments abroad are clearly closely linked.

On the other hand it might be possible to bridge the gap not by an expansion of exports but by a reduction of imports. This is essentially a less desirable way because it continues the pre-war practice of "beggar my neighbour" and might cause distress and unemployment abroad which could not fail to be re-imported into England. It is, however, possible that after the war there will be a potential inflationary position abroad so that full employment can be maintained even with reduced exports to England, in which case the reduction in imports would be a serious alternative to an expansion of exports. It might also be, of course, that the reduction in imports is the only possible way of bridging the gap if the additional exports cannot be sold at any possible price or any possible exchange rate of the pound sterling.

There are two kinds of imports which might be reduced. In the first place, those which might be classed as "unessential," such as, for instance, luable furs. In the second place, there are imports of goods which might be produced with almost the same efficiency of labour in England. Oil refining might be in this category, so that England could reduce her imports by eliminating the import of the services of refining, and importing crude oil instead of refined.

Thus it might be possible by judicious import controls and by scientifically applied restrictions to keep the fall in standards of living due to the loss of foreign investments within certain well-defined limits. Some loss would, however, be inevitable. The loss would, of course, be even greater if selective restriction of this kind were to provoke international retaliation in other countries and lead to a new version of that international economic warfare of pre-1939 memory which went by the name of "foreign trade." It is also quite possible that import control will be ruled out by general international agreement. In this

case the only way of achieving the extra exports required, now that the foreign investments are gone, would be by a low exchange rate for the pound sterling. This would make British exports cheap to people abroad, but imports dear to people in England. This depreciation of the pound sterling would be equivalent to a general tax on all imports, essential and unessential. From a purely English point of view, this would clearly be less advisable than the more selective policy. If exchange rates should be fixed and unalterable the extra exports could only be achieved by a policy of deflation at home designed to lower British costs and British prices. Such a policy would be antagonistic to an expansionist internal economy. Deflation at home would be likely to produce unemployment and industrial unrest; it would also be accompanied by an atmosphere of public parsimony and new "economy campaigns," and this would dash most of the hopes of social reform. Fortunately, however, this prospect of having to expand exports by deflation is not very likely to materialise. The Bretton Woods arrangements make ample provision for changing exchange rates, and under them there would seem to be no need for England to have to choose the way of deflation.

The need for increasing exports, while reducing the standard of living, will make it easier to maintain employment at home. Any increase in exports is inflationary in character. The persons engaged in the making of the additional export goods receive their wages, salaries, profits, bonuses, etc., which appear as new purchasing power in the home market. If no new additional goods are imported to offset this new purchasing power, there will be a condition of relative shortage and prices will rise unless controlled, thus stimulating home production. The stimulation of exports, in a sense, is the smoothest and easiest way of "creating work." In most other methods of work creation the initial stimulus is largely offset when the extra goods appear in the markets. In the case of expansion of exports, however, the extra goods do not appear on the home market at all because they are being sent abroad.

Thus we may sum up by saying that the loss of foreign investments will reduce standards of living in a degree dependent on the way in which the gap is being bridged. At the same time it will make it easier to maintain full employment at home. This, by the way, is a useful reminder that fuller employment, i.e. more work, may be the result of poverty just as well as a means to wealth.

## Foreign Trade and the National Income

The other international factors which we mentioned as having a bearing on the post-war real income are the volume of foreign trade and the terms of trade. As regards the volume of post-war trade, we have reason to be optimistic. The inherent economic tendencies even before 1939 steadily worked in the direction of more international exchange of goods. The idea that progressive industrialisation would reduce the need for foreign trade is a complete myth which can easily be exploded from the available facts.

Even the combined forces of economic nationalism and war-induced self-sufficiency were not enough to lower the volume of world trade below its pre-1914 level. Remove the fear of war, create a new international monetary system, restore reasonably free trade, and the volume of world trade will grow steadily and rapidly become twice or more of what it was before 1939. No country would benefit more from such a development than England. Not only is the share of foreign trade in the national income greater in Britain than in any other major country, but it is also highly likely that the productivity of labour in British export industries is superior to what it would be if imports had to be obtained by home production rather than exports to a degree greater than in any other country. On both counts—i.e., the expansion of exports necessary to offset the loss of foreign investments and the one that might result from the general increase in the volume of world trade—the proportion of people engaged for exports will be much higher than before the war. This will have profound repercussions on the country's industrial structure and industrial organisation. Even if the doubling of world trade may take some time, some expansion in the volume of trade may reasonably be expected. It is reasonable to assume that the benefits derived from the expansion of world trade will offset the loss due to the liquidation of foreign investments.

## Danger of International Disruption

On the terms of trade it is not possible to be so optimistic. We have pointed out already that the greater pressure of selling exports to fill the gap torn by the loss of foreign investments may in itself worsen the terms of trade to England's disadvantage. It might be possible to offset this by using the great importing capacity of the country as a bargaining weapon in bi-lateral trade agreements, and thus obtain better prices for exports. In view of the international disruption such a policy would create and the reduction in the total volume of trade which would go with it, it would probably be a suicidal policy which would do more harm than good.

England's imports consist almost entirely of food and of raw materials very largely produced by agricultural methods, such as cotton and rubber. In the course of improving standards of living among the farmers and primary producers abroad, and also as a part of the industrialisation of previously agricultural countries, the prices of imported food and raw materials will probably have to be higher in the long run than they were before the war. The prices of industrial goods which England exports may also increase in the long run, as standards of living and purchasing power abroad increase. But they could not be expected to increase as much as import prices to the extent that England has to face other industrial countries with great advantages. However, in so far as England can manage to export specialities it may be possible to avoid excessive competition. In any case, there will be a long transitional period in which the terms of trade must be expected to be worse than before the war. The effect of this may again be largely offset by a scientific policy of buying food and raw materials in bulk at favourable prices such as has been suggested by Lord Keynes.

To sum up, then, the effect of the international factors on post-war real incomes: We must expect some deterioration from the loss of foreign investments and a worsening

During the war new factories have sprung up while many that already existed have been extended and re-equipped. The new factories are often better laid out and better supplied with transport, power and other amenities than the older type of factories. Plants such as this tank factory will be a great asset in post-war years.

of the terms of trade, but we may hope for some gain from an expanding volume of world trade in general. On balance, it will be prudent to schedule for some loss on the international count.

## Domestic Output after the War

Fortunately the picture is much rosier as we turn from the international to the domestic factor in the post-war National Income. Domestic output for domestic consumption is, and will be even after the expansion of world trade, the major determining factor in the country's economic position. What forecast can we make in this respect?

In the previous article we have pointed out that the level of domestic output depends on a great variety of circumstances. The most important of these are the amount of national capital (especially of mechanical appliances in industry), the skill, training and education of the population, its numbers and willingness of co-operation, the degree of unemployment, the scale of production, and the quality of management and industrial organisation. The war evidently has a profound effect on all these items which we shall now consider in detail.

As regards the national capital, the mechanical appliances in industry, the immediate impact of the war has been harmful. A certain amount of the national capital has been directly "blitzed." Fortunately this applies much more to social capital of the consumption type, especially houses, than to productive capital such as machinery. With the productive capital largely intact, the loss of social capital can be made good much more rapidly than would be true in the opposite case. There has been a good deal of domestic "dis-investment" during the war, in addition to the direct war damage. Without proper repair and maintenance, and often worked to the limit, machinery has been worn out. This domestic dis-investment, i.e. the failure to divert part of the gross national output for the maintenance of the national capital, has in fact been one of the main ways of paying for the war, as was mentioned in the previous article. According to the Government White Papers, the combined loss of national capital in the first four years of the war due to such domestic dis-investment is reckoned as £760,000,000. Some arrangements have been made to maintain and care for machinery in closed-down plants; but here, too, there must be some deterioration. Against this dis-investment, however, there has been a good deal of new war-time investment, largely public but also private. Not all war expenditure will "go up in smoke." A good deal of it, such as soldiers' equipment, lorries, aeroplanes, machine tools, etc., will be useful for ordinary civilian production perhaps after a certain amount of conversion, or else they may be useful for export. Even the scrap value of such equipment would be quite considerable. In addition, new factories have risen—usually Royal Ordnance factories or agency factories—which are very often better laid out and better planned an better supplied with transport, power and other amenities than the older type of factories. The total value of public expenditure on capital assets as part of the war accounts has risen to a considerable amount. Of the Lease-Lend material a good deal may have to be returned; but it is not certain that the American manufacturers will want it all back.

On the known facts it is reasonable to say that the additions to the national capital in war-time plus the peace-time value of war stocks and equipment will more than offset domestic dis-investment, and will go a certain way to offset direct war damage as well. It will probably come near the truth to say that the end of the war will see us roughly where we were at the beginning, or that the war in this respect will have thrown us back by the amount of progress that could normally have been expected during these years.

As for the skill of the population, the war has brought immense enrichment, and there has been a greatly exten-

County Borough of Merthyr Tydfil
The inhabitants of the Borough are invited to attend
a
Public Meeting
to be held at
THE MINERS' HALL.
Monday Evening, the 8th day of November, 1937, at 7, to consider the matter of presenting
A Petition from the Town to The Prime Minister
urging upon him the necessity of the Government taking immediate steps to provide employment within the Borough for the thousands of unemployed workmen who reside therein.
The Members of the Development Committee of the Borough will be present.
All interested are heartily invited to attend.
D. J. EVANS,
MAYOR

After the war Governments will be judged on their record in maintaining employment. Few will forget the dereliction of factories and workers in the inter-war years. The photograph above shows what was once part of a steel works in Merthyr Tydfil. In that town there used to be some 7,000 steel workers; by 1930 only 3,000 were employed. In 1937 over 60% of the town's workers were unemployed. The poster speaks for itself. Dr. Singer suggests unemployment can be kept down to 5% of the total population.

ded volume of training. Large numbers of women have gained not only industrial experience but also industrial skill. The schedule of reserved occupations has reduced the drainage of skilled personnel to the Services. In the Services itself work has become much more similar to industrial employment consisting, as it does very largely of the servicing of machines and tools. A good deal of training which will be useful for industrial purposes has actually been done within the Army itself. A number of weapons of war evidently hold out peace-time possibilities (not excluding the flying bomb). It is to be noted that a good deal of war-time training both in the Services and in war industry is in the field of engineering, i.e. exactly where it will be most useful for purposes of post-war employment. Not only the amount of total skill available in the population has increased but also facilities for the training of new people and our knowledge of how to do it. On this count, therefore, we can register much progress. The main post-war problem in this field will be to see that this progress is not wasted by new artificial exclusion of women from skilled work or by a revival of absurd demarcation rules or objections to dilution of labour.

As to general education among the population, the war has probably brought certain setbacks. War-time conditions have disrupted schooling, teachers have been called up, university education has been hampered by the call-up of students and by reductions in staff. But at least we can say that during the war there has been a growing realisation of the enormous importance of a high general level of education as an economic factor in an industrial exporting nation. This state of public opinion and the passing of the Education Bill make it certain that in this respect we shall do much more than before the war. Although the economic benefits of the improved level of education will be somewhat delayed and not readily measured by the statistical rod, there are bound to be immense strides if educational facilities are not only increased but also equalised in the process.

The haphazard selection of the entrants to that educational stratum from which the skilled and key jobs in our economic system are filled has been one of the major drags on standards of living for a long time past.

Technical knowledge has been rapidly increased during the war. Many of the war-time innovations, of course, are still shrouded in mystery, at least to the outsider. Many others will need some further development before they can be applied to the production problems of peace-time. But from what has been stated by public spokesmen and from the optimism of the insiders it seems safe to say that technical progress has been more rapid than what would normally have occurred. Again, it is not only what *has* already been achieved by scientific research which opens up fairer prospects for the post-war real income, but perhaps even more so the setting for continued progress which has been achieved. The State and private bodies, too, have taken a greater interest in scientific research and organisation. This interest is already reflected in higher grants and in special fiscal concessions. This new interest is bound to continue after the war. The undue neglect of scientific research is an inevitable drawback to a system based on sectional ownership impelled by the immediate profit incentive. This recognition is another great asset compared with the post-war position.

## Employment and Output

On an average some 14% of the total population were involuntarily unemployed between the two wars, and thus failed to contribute to the national income. A certain amount of involuntary unemployment is inevitable though it need be very much less than the percentage which the Government assume in their White Paper. It must also be taken into account that a large proportion among the unemployed are unskilled and elderly, so that their employment would not increase the national income in proportion to their numbers. Since 1939, war-time

conditions and the operation of the Essential Works Order have greatly increased the powers of the State to provide employment and its knowledge of how to do so in the private sector as well. In the White Paper on Employment Policy the Government has formally assumed the responsibility for full employment. The White Paper has been criticised—and rightly so—as not being far-reaching enough and also as containing some unresolved contradictions. Even so, the policy outlined in the White Paper, if systematically applied on what we may assume to be a more favourable national and international background, promises fuller employment than in the pre-1939 era, probably sufficient to reduce average unemployment to perhaps 5% or so of the total population, and thus add some 5% to the pre-war national income.

Here again I should place hopes not so much on the direct benefit—welcome though it is—but on the indirect results of maintaining employment. The fear of unemployment has been more destructive than unemployment itself. It has led on the labour side to such harmful results as limitation of output, restriction of apprenticeship, refusal to accept trainees and dilutees, artificial demarcation rules for jobs, etc. On the management side, fear of unemployment and recurrent crisis has resulted in an excessive reluctance to take risks in installing new machinery, etc., and in a groping for an illusory security by restrictive agreements, formation of closed rings, rising tariff walls, etc. These restrictive practices on both sides have perhaps done more than any other single factor to reduce real incomes. They are deep-rooted and will take some time to eradicate. The abolition of mass unemployment and recurrent trade depressions is the first step towards getting rid of these suicidal practices. If the *real* security provided by a steady and expanding national income in combination with proper social services can replace the vain quest for sectional security by restriction, the road to a heavy expansion of the national income will lie open.

## Management and Organisation

The final factor we shall consider is the quality of management and industrial organisation. Here again the war has resulted in great strides forward. Management is becoming more and more a science, with psychology, physiology, statistics, economics and others called in to support it.

Under the pressure of scarcity of labour, management has become more amenable to organisation of new types of employment, especially part-time employment. Part-time employment holds great post-war prospects as a method of enabling the war experience and training of women to be retained for industry. Curiously enough, real scientific management—not the parody which was thus misnamed in the pre-war period—is more humanised than before. The importance of proper welfare arrangements, of decent human relations between management and labour, of the workers' interest in the processes of production itself, and ultimately of the workers' acceptance of the purpose and essence of the economic and social system, all these are beginning to be more and more clearly realised. Further progress along these lines seems inevitable after the war.

## General Conclusions

We have now reached the end of our summary. The pattern which has emerged is one of confused crossing and overlapping trends. Nothing else could be expected. The impact of total war on a social and economic fabric which is both complex in itself and embodied in a complex manner into a world-wide system can be nothing but complex and contradictory in itself. Many of the factors mentioned are not subject to precise statistical forecast in advance. The reader may have noticed that it is largely the losses compared with the pre-war position which can be summarised statistically, while the gains are often intangible. This fact in itself, as well as a natural tendency not to count chickens before they are hatched, may account for a certain pessimism. But it seems equally wrong to fail to count chickens which are in process of hatching. The author's own recommendation is to think of the post-war National Income in the period immediately after the Japanese war, as equal to the pre-war income, and to assume that in the absence of new wars, etc., it will be raised to a level some 25% above the pre-war National Income per head within five or six years, to about 50% above it in a further eight years, and that from then onward it will increase at the rate of about 3% per annum, which is about twice the pre-war rate. There are two great provisos, of course, to this forecast. One is the avoidance of new wars, and the other the avoidance of a progressive decline in population.

It may be helpful to some readers to have the factors dealt with in this article summarised in a table. The following table shows on the plus side the various factors which will tend to raise the post-war National Income above the pre-war level, and on the minus side the factors pulling it down.

| *Plus* | *Minus* |
|---|---|
| Expansion of world trade. | Loss of foreign investments. |
| New war-time inventions. | Deterioration in terms of trade. |
| New war-time factories. | War damage. |
| Reduction in unemployment. | Domestic dis-investment. |
| Increased skill and training. | Reduction in numbers due to war losses. |
| Extended education. | Reduced education in war-time. |
| More scientific research. | |
| Reduction of restrictive practices. | |
| Scientific management. | |

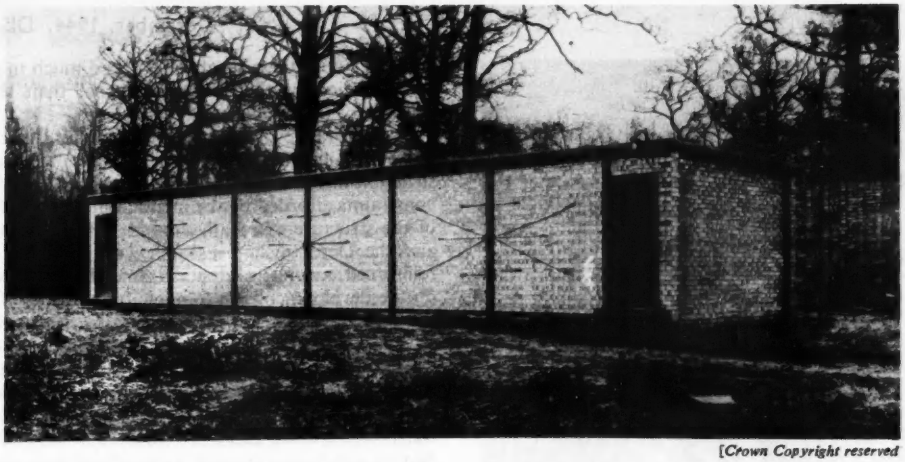

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FIG. 1.—Heat transmission laboratory for measuring the rates of heat loss through walls (thermocouples for surface temperature measurements can be seen attached to the test walls).

# Scientific Standards for House Construction

CONTRIBUTED BY THE BUILDING RESEARCH STATION

AFTER this war, there will be a prodigious demand for houses; and in satisfying the demand we shall have to use various alternative forms of house construction, with which usefully to supplement what can be provided by traditional means. In making sure that such alternative forms are in fact satisfactory, clear thinking is necessary on what are the fundamental requirements. The structure must be strong and stiff; it must keep out damp; it must be reasonably easy to keep warm; it should provide quiet—insulation against the neighbour's wireless, etc.; it must not present an undue fire risk; it must be durable; and it must not be liable to be vermin-infested; or, if it does become infested, be difficult to disinfest.

With the traditional brick house, experience alone had evolved a reasonably satisfactory structure and there had never been any incentive to enquire closely into these matters. But in appraising new designs incorporating quite different forms of construction, the adoption of a scientific approach to the problem became essential. Standards had to be established for the degree of thermal insulation of the outside walls, for the soundproofness of party walls, and for all other properties which determine the performance of a house. This has now been attempted for the first time in the report of the Interdepartmental Committee on House Construction (the Burt Committee)[1] with the preparation of which the Building Research Station has been closely associated. The absence of guidance on these points was responsible for some of the troubles encountered with new forms of construction after the last war.

The contribution made by research in the establishing of these standards is discussed in the following sections.

## Strength and Stability

With traditional materials, the thicknesses of load-bearing walls were primarily determined by the need for thermal insulation and weather resistance, and these thicknesses gave more than adequate strength. The floors and roofs were mostly of timber and the scantlings adopted as a result of experience to give adequate stiffness (lack of flexibility) resulted often in a considerable reserve of strength.

With the development of methods of obtaining adequate insulation and weather resistance without recourse to thick walls, and the desire for breaking structural continuity for acoustic insulation, the stability of the building has become a matter for investigation. The problem is in two parts: first, the evaluation of the loads, particularly the superimposed loads, to which the walls, floors and roof of a house may be subjected; and second, the estimation of the ability of the structure to resist those loads.

The superimposed loads comprise: (*a*) normal loading on floors due to furniture and occupants and (*b*) wind, snow and other incidental loadings external to the structure. No detailed study of floor loadings in houses has been made in this country, but a survey[2] of office loadings made by the Department of Scientific and Industrial Research in 1930 indicated certain general features, such as the comparatively low average value of the loading when a large area is considered and the considerable decrease in the maximum load per unit area as the area considered is decreased, which are applicable to house floors. The figures for floor loads now suggested are well on the safe

[1] House Construction: *Interdepartmental Committee on House Construction, Ministry of Works, Post-war Building Studies No.* 1. London, 1944, (H.M.S.O.), 2*s*.

[2] Survey of live loads in offices: C. M. WHITE: *First Report of the Steel Structures Research Committee, Department of Scientific and Industrial Research*, London, 1931 (H.M.S.O.), 5*s*.

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FIG. 2.—Lifting a floating floor out of contact with the sub-floor to secure good sound insulation. (An additional concrete floor slab is laid with a number of screwed collars incorporated, and is finally lifted from the sub-floor by screwing plugs into the collars so as to bear on small resilient pads placed on the sub-floor. The partition walls are built on this floating floor).

(i.e. high) side for most dwelling houses, but it is necessary to allow for the worst conditions that may reasonably occur.

With a light prefabricated type of house, the distorting loads due to wind may be of first importance in determining the stability of the structure. Research on wind forces has in the last 20 years yielded much data which is of direct value in design. This research, carried out by the National Physical Laboratory for the Building Research Board has included measurements of pressure on model buildings of various shapes in a wind tunnel and measurements of pressure on actual buildings in natural wind. The shielding effects of one building on another have also been examined and practical rules have been evolved for allowing for wind in the design of buildings. It was found that the local pressures on roof coverings, windows, wall panels, etc., were markedly affected by openings in the walls, leading to internal pressures which may augment the effects of the external pressure. In fact, for many types of house these local effects need much more careful consideration in the structural design than the general stability of the building as a whole.

The accurate estimation of the ability of the structure to resist the imposed loading is difficult for house construction in which considerable strengthening results from constraints afforded by the interaction of the various parts of the structure. In framed houses the position is easier, and the Department's research work of recent years on reinforced concrete and steel frames has a direct bearing on the development of economic frameworks of adequate strength. For load-bearing wall construction, considerable advances have been made, as a result of research, in the design and control of concretes using lightweight aggregates, and work on the strength of brickwork masonry has also helped in assessing the strengths of relatively thin walls stiffened by piers on cross-walls. Concrete floors may be widely used as an alternative to timber, and research work on reinforced concrete beams and slabs has indicated several useful approaches to reducing the tendency for increased dead weight with such floors. (Fig. 4).

## Thermal Insulation

The problem of the desirable thermal insulation to be provided by building structures is essentially an economic one. It is important that the right standard of insulation should be adopted. If the standard is low, fuel is wasted, while if it is too high the cost of it may be excessive. Research has helped in determining this optimum amount by providing the necessary data on the insulating values of the different materials and construction.

The National Physical Laboratory is well equipped for studying in its laboratory the rates of heat flow both through simple materials and through composite structures, and has tested many building materials.

This work has been supplemented by tests at the Building Research Station on wall panels exposed to the weather, for in practice the rate of heat loss from any part of a building will depend not only on the thicknesses and conductivities of the materials employed, but also on the situation of the building and on the degree of exposure to wind, sun and rain.

A special laboratory erected in 1936 at the Building Research Station for such work is shown in Fig. 1. The laboratory comprises six small rooms placed side by side each with a test wall, which can be changed as required, facing north. The building is heated electrically and the heat lost through each test-wall in any period can be determined as the difference between the heat input to the particular room and the relatively small amount of heat which has escaped other than through the test-wall. It is thus possible to determine the rate of heat loss through various wall constructions under natural conditions of exposure.

Data on heat transmission through building structures obtained in these and other ways, coupled with information as to the average amount spent on house warming, have served to suggest that it should prove economical to have more thermal insulation in houses than is commonly provided, and tentative standards have been formulated. Adherence to these values should ensure that a house when built will not be costly to heat.

## Sound Insulation

In 1900 W. C. Sabine of Harvard University published the results of researches [3] which laid the foundations of the modern study of the acoustics of auditoria, etc. Later he turned his attention to the separate problem of sound transmission in buildings, and shortly before the last war he made suggestions for a special laboratory for insulation studies, the building of which was completed about 1918.

This laboratory became the forerunner of others throughout the world. Its special character lay in having two insulated rooms with an opening between them in which to insert the test panels. It was used for measuring air-borne sound (representing conversation, music, and so on) through walls, and between 1920 and 1930 a great many such measurements were made. The work brought to light the fact that the sound insulation of solid walls depended on their weight, and that for each appreciable improvement in insulation the weight of a wall had to be about doubled. This had great importance because it meant that adequate insulation by weight alone was impracticable.

By the early 1930's it was realised—very forcibly in England—that sound insulation standards in modern flats and houses were not good enough. In fact, with the development of framed buildings with high engineering efficiency the sound insulation provided was getting worse instead of better. For example, a recent survey made for the Building Research Station showed that about twice as many people complain of noise in modern framed flats as compared with the older load-bearing brick buildings. Moreover, the noises complained of were not only of the air-borne type which had already been studied in laboratories, but also of impacts, such as footsteps and the closing of doors. It was therefore decided to accelerate the research work and to include in it impact studies as well as comprehensive studies of floors and walls in combination in full-scale buildings, for it had become apparent that laboratory studies of isolated walls and floors did not tell the whole story.

The new programme was attacked jointly by the National Physical Laboratory and the Building Research Station, with architects, engineers and physicists working together as a team. The work prospered, and by 1937 it was possible to include in a report on *The Construction of Flats for the Working Classes* [4] a comprehensive list of impact insulation measurements on floors, and also suggestions for minimum standards of impact insulation. By 1940 a further step was made when the Building Research Station was able to publish a report [5] giving direct practical guidance to designers on methods of reducing sound transmission (see Fig. 2).

Tests have been made of the results under practical conditions. An important problem was that of party walls between houses. With the co-operation of a builder in the west country a number of houses was built with cavity party walls to a special, but quite simple detail, for the usual 9 in. solid brick party wall is commonly a source of complaint. The result was a standard of insulation which one could not have expected with less than several feet of solid masonry.

Another important trial was the treatment of floors in a block of working-class flats in London. The treatment consisted of a raft of boarding on battens supported from the concrete sub-floor on an insulation quilt. Ordinarily the same raft would have been held in clips. The result was a very satisfactory improvement.

With this background it was possible to approach with some confidence the problem of indicating what standards of sound insulation, expressed in precise scientific terms, should be provided in dwellings against air-borne and impact sounds.

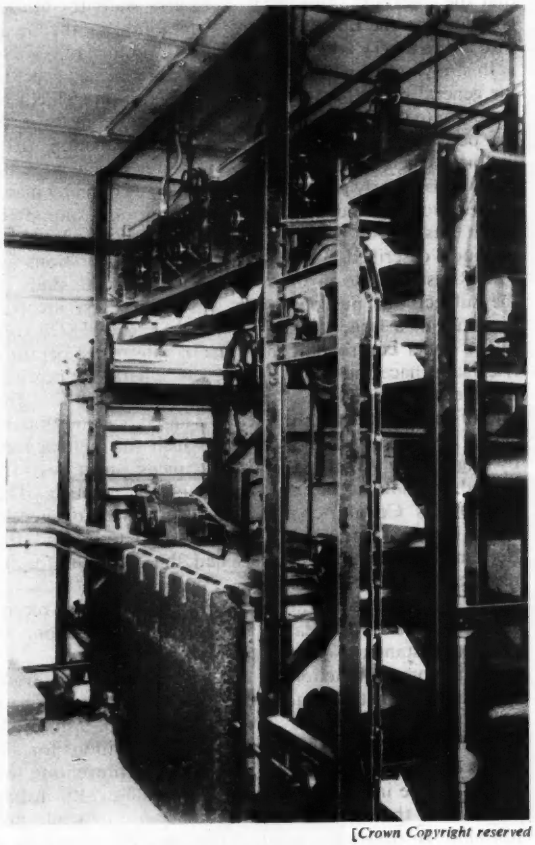

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FIG. 3.—Accelerated weathering plant for bituminous materials. (Samples of asphalt, etc., in metal trays move slowly round the apparatus and are subjected in turn to ultra-violet radiation, heat, rain and frost. The cycle is repeated until the materials show signs of failure).

## Fire Hazard

The acceptable standard of safety against fire hazard attained by the traditional brick house is the result of many years of development, and it is interesting to note

[3] Collected papers on acoustics: W. C. SABINE: Cambridge Mass., 1922 (Harvard University Press) 21*s*.

[4] The construction of flats for the working classes: Final Report of the Departmental Committee: MINISTRY OF HEALTH: London, 1937 (H.M.S.O.), 1*s*.

[5] Sound transmission in buildings: R. FITZMAURICE AND W. ALLEN: London, 1940 (H.M.S.O.), 4*s*.

that the thickness of external and party walls for houses laid down in the Building Act of 1667 following the Great Fire are to a very large extent followed to this day.

In studying the new forms of construction one aspect of the general problem is the fire resistance of an element of structure (e.g. a wall, floor or column) defined in terms of the period for which it will continue to function satisfactorily when exposed to fire and water under working conditions. Early work in this country was done by many bodies, notably the British Fire Prevention Committee, but it was not until the formulation of the standard test methods, described in the British Standard Definitions for Fire Resistance No. 476 issued in 1932, that the study of the subject was put on a firm basis. The test involves exposure of a large specimen of the element of structure to fire under controlled conditions of rate of temperature rise in a furnace and in some cases, after a period of heating, to water to simulate the effect of the fireman's hose. The rate of temperature rise adopted was based on conditions in actual fires, the scientific study of which was commenced by Ingberg in America. The specimens under test are loaded, or not, according to their use in practice. The Fire Offices' Committee provided a laboratory, opened in 1935, for the conduct of these standard tests, and the Building Research Station has had the use of it for its researches into the subject.

The results have had an important application to recent consideration of standards for house construction, in particular, standards for the party wall.

An important function of the party wall is to prevent spread of fire between adjoining houses, and in the past a 9 in. solid brick wall has been required. The 9 in. brick wall in fact survives the standard test conditions for six hours or more and it would be effective in preventing the spread of fire in a heavily stocked warehouse. But it has been found that the fire in an ordinary house would not normally be equivalent to more than one hour's exposure in the standard test, so that a six-hour fire resistance is more than is required. The Interdepartmental Committee on House Construction has now adopted two hours' resistance as an adequate standard. In other words scientific research has indicated that a new form of construction, which is otherwise attractive, need not be condemned merely because the party wall construction does not offer a fire resistance as high as that provided by the 9 in. brick wall.

Space does not permit discussion of other important aspects of the general problem of providing fire protection in buildings; but it may be said that here again systematic investigation, including the study of war-time fires, has been very fruitful.

## Damp Penetration

Damp penetration in houses is a very common source of complaint, but unlike the properties discussed above it cannot be dealt with on a quantitative basis. This same difficulty arises in estimating durability and the liability to bug infestation, discussed in the following two sections, but nevertheless research has been fruitful in giving clearer guidance.

The effects of damp penetration vary from minor disfigurement of decoration to serious structural damage by "dry rot", quite apart from any effect on the health of the occupants. With traditional forms of construction, experience alone has pointed the way to precautions necessary to avoid damp penetration. The function of research in this field has been to examine more closely the way in which moisture enters, penetrates through and escapes from walls, so as to bring out the underlying factors for more general application in design.

Taking the case of a brick wall, quite often the easiest way for rain to penetrate it is not through the bricks or the mortar but by way of capillary cracks between the two materials. Thus a dense brick set in a dense mortar does not necessarily give a rainproof wall. A moderately porous type of brick which will absorb rain (and so prevent it from running down and turning in at a crack) during a shower, and yield it up externally again when drying conditions return may well be better.

This same point arises with Portland cement renderings and thin concrete walling units. These, if too dense and strong, tend to shrink and crack and admit rain, but when made weaker and more porous this tendency is reduced, yet the material will remain reasonably proof against rain penetration.

The main point that emerges is that, before the materials for the wall are decided on, the designer must be clear as to how he proposes to keep out damp. For instance if he proposes to use an impermeable outer cover, care must be taken that the design and construction is not such as to lead to capillary cracks through which water will enter.

Another aspect of dampness in houses is that of condensation of moisture on internal surfaces. This is a different problem from damp penetration and is closely linked with those of the heat transmission and moisture-absorbent properties of building materials and the heating and ventilation of rooms—each of which has been and still is the subject of research.

## Estimating Durability

The probable length of useful life of a new form of house construction is obviously an important consideration. It is virtually impossible to predict it with any accuracy but it is possible to obtain useful indications from laboratory work.

Any material exposed in a building is subjected continuously to a number of physical conditions. Obviously, the relative importance of one or other of these depends on the position of the material in the building—whether for example, it is on the outside or inside.

Taking the case of external exposure as an example, and neglecting for this purpose such rather special conditions as exposure to sea-spray, the various effects of weathering may be enumerated as follows:

(i) The effects of heat and of ultra-violet rays from the sun.
(ii) The effects of rain and frost, particularly in cycles of freezing and thawing.
(iii) The effects of rain and sun in alternately wetting and drying.
(iv) The effects of rain in dissolving constituents and carrying them away in solution.

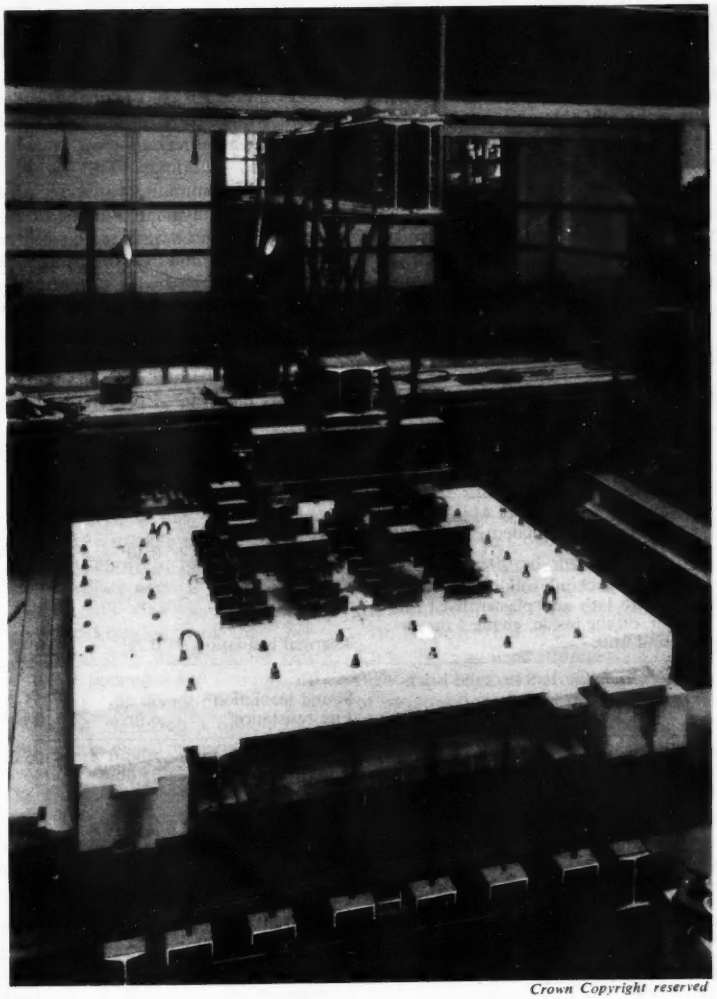

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FIG. 4.—Testing a concrete floor slab. (The slab is fixed on four edges to represent continuity with walls and neighbouring floor bays, and is loaded through a "pyramid" of steel to give uniform loading on the slab area. Extensometers are fixed on the slab to measure the stresses set up).

(v) The chemical or physical reactions brought about by transfer of the dissolved constituents from one part to another, or to or from a different type of material adjacent to that under examination.

(vi) The chemical and physical reactions of the material with oxygen, carbon dioxide, acid gases and soot.

The relative importance of these effects varies according to the material; some materials are more sensitive to one, some to another, but as a result of research and experience it is possible in most cases to give useful information on a new material, to say to which factors it is likely to be sensitive, and to pay most attention to these in laboratory tests.

The tests themselves are often of the "accelerated weathering" type. Thus the effects of heat, ultra-violet rays and rain, together sometimes with those of frost may be determined for some materials, particularly the bituminous materials, by exposure to laboratory cycles of heating, ultra-violet rays, water-sprays, etc. (see Fig. 3). Effects with other materials are not so readily capable of being imitated by accelerated tests in the laboratory, and judgment on the probable behaviour of the material has to be based on systematic research on parallel problems. The chemical effect of salts dissolved by rain and carried about the fabric of the building is an example.

It would be expected that the effects of freezing and thawing could easily be observed by accelerated tests. Many building materials, including concrete, brickwork and stone, are damaged by frost under suitable circumstances. In fact, however, it is not yet possible to use one accelerated method of freezing and thawing as a universal test for any material and the laboratory results are not too good a guide to the behaviour in practice.

In most cases, the destructive effects of weathering can be retarded by suitable maintenance measures, but maintenance items are a recurring expense, to be avoided if possible. The laboratory examination helps to indicate whether maintenance is likely to be abnormally heavy or not..

## Bug Infestation

The infestation of houses by vermin is a common problem. "Vermin" includes rats, mice, cockroaches, crickets and fleas, but probably the commonest and most serious form of the infestation of dwellings is that by the bed-bug, which may arise with new as well as with old and dilapidated buildings. This problem is fundamentally a social one demanding for its solution higher standards of education and hygiene, but the designers of buildings can contribute in three ways to the efforts of educators, public health officers and housing managers to eradicate infestation by bed-bugs.

Firstly, buildings should be designed so as to be easily

TABLE I

## PERFORMANCE OF BRICK HOUSE IN RELATION TO PROPOSED STANDARDS

| *Element of House.* | *Requirement.* | *Value.* | *Desirable Standard.* | *Value compared with Standard.* |
|---|---|---|---|---|
| *Outside wall:* 11 in. cavity wall (two leaves of 4½ in. brick separated by a 2 in. air space, unventilated), plastered internally. | Thermal Insulation. | 0·30[1] | 0·15–0·20 | Low. |
| *Outside wall (Scottish Practice):* 9 in. solid brickwork, roughcast outside and with lath and plaster fixed on battens of 1¼ in. by 1 in. on the inside, giving 1 in. air space between plaster and wall. | Thermal Insulation. | 0·28[1] | 0·15–0·20 | Low. |
| *Party wall (wall separating two houses):* 9 in. solid brickwork, plastered on both sides. | Sound insulation[2]<br>Fire resistance[3] | 50 db.<br>6 hr. | 55 db.<br>2 hr. | Low.<br>Ample. |
| *Partitions* (walls between rooms which give no support to the structure): 2½ in. clinker blocks, plastered on both sides. | Sound insulation between living room and other main rooms.<br>Between other main rooms. | About 35 db.<br>About 35 db. | 45 db.<br>35 db. | Low.<br>Adequate. |
| *Ground floor:* ⅞ in. (1 in. nominal) tongued and grooved floor boards on timber joists, ventilated underneath, covered with lino.<br>Wood block floor on concrete laid direct on ground. | Thermal insulation.<br>Thermal insulation. | 0·25<br>0·15 | 0·15<br>0·15 | Low.<br>Satisfactory |
| *First floor:* 1¼ in. floor boards on timber joists; lath and plaster ceiling under joists. | Sound insulation, air-borne.<br>Sound insulation, impact. | 35–45 db.<br>Standard. | For flatted dwellings only 55 db.<br>+20 phons | For flatted dwellings only, low.<br>Low. |
| *First floor (Scottish practice):* ⅞ in. (1 in. nominal) tongued and grooved floor boards on joists. Trays of ⅜ in. board fixed between the joists carrying 3 in. of ashes. Lath and plaster ceiling under joists. | Sound insulation, air-borne.<br>Sound insulation, impact. | 50 db.<br>+10 phons | 55 db.<br>+20 phons | Low.<br>Low. |
| *Roof:* Tiles fixed on battens with continuous layer of felt between this and the rafters. Lath and plaster ceiling under ceiling joists. | Thermal insulation. | 0·43 | 0·30–0·20 | Low. |
| *Roof (Scottish practice):* Slating direct on felt underlay on ⅞ in. sarking (boarding). Lath and plaster ceiling under ceiling joists. | Thermal insulation. | 0·35–0·30 | 0·30 | Low. |

[1] Thermal insulation figures are expressed throughout in terms of "U" the transmittance co-efficient. A high value of this co-efficient means low insulation.

[2] The values given for sound insulation refer throughout to the reduction of *air-borne* noise, except where impact noise is specifically mentioned. The decibel (db.) is a unit of measurement of sound energy and is usually used for measuring *air-borne* sound. The phon is a unit of loudness (not necessarily equivalent to the energy) and is usually used for the measurement of impact noises.

[3] As tested under the standard conditions laid down in *British Standard Definitions* (No. 476, 1932).

cleaned. Dr. William C. Gunn, has written "no-one who keeps a clean house need fear its invasion by the bed-bug". While the chief responsibility for this must be upon the occupants, the designer can assist, for example, by generous and straight-forward planning, giving easy access to all parts; by careful design in detail, avoiding unnecessary lodgment for dust and dirt; and by providing adequate natural and artificial light in all parts.

Secondly, design should be directed to reducing the potential harbourage for the bed-bug to a minimum. Serious infestation of a building can only take place when the bugs have obtained a foothold in the fabric of the building, and this can only occur when the fabric affords cracks and crevices in which they can live concealed and undisturbed except when they come out to feed. While it is probably impossible completely to eliminate all the potential harbourages in any form of construction, it is possible to reduce them by a careful consideration of the fabric, finishes, trim, equipment and services with the menace of infestation in mind.

Thirdly, bearing in mind at the design stage that chemical disinfestation may have to be applied at some time in the future, the application of that process may not only be facilitated and cheapened, but also made more effective.

Though the designer has an important part to play in eradicating bed-bugs, the immediate need is for effective methods of control. Until recently this has been much hampered by lack of scientific knowledge of their life-habits, a knowledge of which has been proved in the case of other insect pests to be a necessary preliminary to satisfactory methods of control. In 1935 the Ministry of Health invited the Medical Research Council "to promote new investigations with a view to a better understanding of bed-bug infestation and of practical methods for dealing with it". The Council appointed a Bed-bug Infestation Committee which carried out extensive investigations into the subject between 1935 and 1940, publishing a summary of its findings[6] in 1942.

[6] Report of the Committee on Bed-bug Infestation, 1935-40: MEDICAL RESEARCH COUNCIL: London, 1942 (H.M.S.O.), 1s.

These investigations have added much to the knowledge of this subject and, among other results, have led to the development of a fumigation technique using heavy naphtha which seems to promise a big advance in the practice of disinfestation.

## Conclusion

It is of interest to see how the conventional brick and timber house stands in relation to some of these quantitative standards that have now been suggested. This comparison is shown in Table I, taken from the report of the Interdepartmental Committee, but with the first column modified to describe the structural elements at greater length. The table gives the suggested standards for thermal insulation, sound insulation, and fire resistance, and the corresponding values for the brick house.

The Interdepartmental Committee has only concerned itself with those factors which have an important bearing on the consumption of labour and materials in building and has not dealt with other factors, notably day lighting. All aspects of building will, however, be covered by the comprehensive series of Codes of Practice now being prepared by the Codes of Practice Committee, formed by various professional institutions under the aegis of the Ministry of Works. Science will again play a big part in the formulation of these codes.

It is clear that the report of the Interdepartmental Committee by itself represents a big advance in the design of house construction. Obviously designers of new forms of construction should not be rigidly tied to the standards set by the brick house, for in some respects they are unduly restrictive and in others they do not reach standards that should be attempted. The Committee note in their Report that "For one reason or another, it may be difficult in the immediate post-war years to realise all the suggested standards: nevertheless they should represent the aim until sufficient further experience has been gained to warrant a review of them." This aim could not have been defined without scientific research.

# Leading Bees to Honey

THE doctrines of the Russian physiologist Ivan Pavlov have proved to be of great value in many branches of science and practice, and his theories of conditioned reflexes and of the higher nervous activity are finding a wide field of application in Soviet agriculture. One interesting instance of their use may be cited from the field of beekeeping. It was Darwin who pointed out that the Central European bee does not pollinate common clover, with the result that this valuable agricultural plant yields very little seed. Soviet beekeepers decided to apply Pavlov's ideas in an attempt to overcome the bee's inhibition in this connection and to induce in them an artificial conditioned reflex responding to the scent of clover. For this purpose, A. Gubin recommended that a sweet syrup should be made from the clover heads at the time the flowers were beginning to open, and that this syrup should be placed in the hive, the exit from which is then closed so as to prevent "competition" from the scents of plants from which the bees are accustomed to sip.

The bees, compelled for three or four days to feed on nothing but clover syrup, acquire in this period, it is claimed, a very strong conditioned motor reflex. When the hive is at length opened the bees make straight for the fields of clover and pollinate the flowers. Their failing to do so before was not due to the fact that the Central European bee has a short proboscis, but rather to the fact that the absence of the necessary conditioned reflex, or association, prevented them from making a little additional effort.

This new reflex proved of benefit both to the bees and to the clover crop. In experimental apiaries in certain parts of the Soviet Union (e.g., the Kalinin region and Kazakhstan) the honey harvest showed an increase of 50-100%, and the crop of clover seed a 7 to 8 fold increase. The success of this experiment was demonstrated at the Moscow Agricultural Exhibition in 1940. The idea of training bees has since become very popular among Soviet farmers: if for any reason there is a shortage of plants from which the bees are accustomed to take honey, they are trained by Gubin's method to visit other plants.

PROF. Y. FROLOV.

In the first part of this article, published in DISCOVERY last month, the author dealt with the production of ethyl alcohol. He continues with a review of the fermentation that yields butyl alcohol and acetone, and shows how its development has influenced the progress of synthetic rubber manufacture. The article will be concluded in next month's issue, when Mr. Colman Green will write about an interesting miscellany of substances produced by moulds and bacteria, including penicillin, acetic acid and citric acid.

# Micro-organisms on Production

## A SURVEY OF INDUSTRIAL FERMENTATIONS

G. COLMAN GREEN, B.Sc., F.R.I.C., A.M.I.Chem.E.

THE rise in importance of industrial alcohol, even for peace-time uses, during the past century has presented a astonishing story. It may be matched by the romantic narrative of the butyl alcohol-acetone fermentation. Pasteur was the first to detect butyl alcohol as a fermentation product, and he encountered it as a by-product formed in a butyric acid fermentation which he carried out. Acetone, however, was not detected as a product of fermentation until as late as 1905.

The development of the butyl alcohol-acetone fermentation has been closely connected with the progress of synthetic rubber manufacture. It is not generally realised that the problem of synthetic rubber manufacture is only just three decades old, although the laboratory discovery of rubber-like polymers dates back to 1860; still less is it recognised that the pioneer work—as in the case of dyestuffs—was carried out by British chemists, but full commercial exploitation was left to other countries. The absence of a virile chemical industry, which is the corollary of a flourishing dyestuffs manufacture, brought this country to the brink of disaster in 1914; so, also, did the absence of a synthetic rubber industry in 1941.

### Early Work on Synthetic Rubber

In 1910 a far-seeing firm of research chemists in the Isle of Wight, Strange & Graham, Ltd., planned a thorough exploration of the possibility of manufacturing synthetic rubber. A team of workers was collected which included A. J. W. Bliss, H. Davies, H. M. Elder, Professor A. Fernbach, T. Kene, F. E. Matthews, Sir W. H. Perkin, C. A. Pim, Sir R. W. Pope, Sir William Ramsay, P. Schoen, E. Halford Strange, C. Weizmann and E. C. B. Wilbraham. The work was planned consequent upon Matthews's discovery of the use of sodium as a polymerisation accelerator (an observation made simultaneously by Harries in Germany) which was patented in 1910. The substances then available for polymerisation to rubber-like materials were isoprene, dimethyl-butadiene and butadiene, derived respectively from isoamyl alcohol, acetone and butyl alcohol.

Isoamyl alcohol is obtainable as a by-product of alcoholic fermentation, being drawn off as a heavy fraction from the lower plates of the rectifying column and being produced by the action of the yeast, not on the sugars in the wort, but on the amino-acids leucine and isoleucine by a process of deamination and decarboxylation. The quantity available naturally fluctuates with ethyl alcohol production and the world's production was about 4,000 tons in 1912. It is produced in relatively small quantities amounting to about ¾ gallon per 1000 gallons of ethyl alcohol obtained from molasses, the quantity being roughly doubled by the use of grain as a raw material.

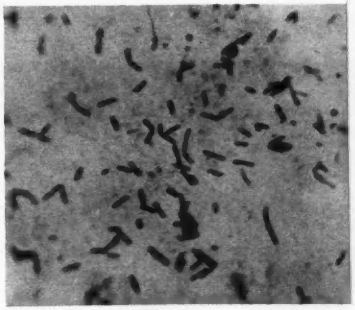
Acetone was available in reasonably good supply from the destructive distillation of wood, while butyl alcohol was not available at that time in commercial quantities at all. However, an alternative to the use of butyl alcohol for butadiene synthesis was ethyl alcohol. It is one of the odd twists of history that, whereas the route from ethyl alcohol has since become highly developed in Germany and Russia and has ultimately been adopted by the United Nations in the manufacture of synthetic rubber to replace the output of the lost Malayan plantations, the British workers never followed it up. From his address to the Society of Chemical Industry in 1912 it is quite clear that Perkin entertained the use of ethyl alcohol as a starting material; but, as Dr. P. Schridowitz has pointed out, the sugar and starch-producing industry throughout the world was at that time in a state of flux, a fact not conducive to the adoption of these products as a raw material for so comprehensive a venture as was contemplated. But this could not have been a valid reason for not proceeding via ethyl alcohol since it seemed likely that, whatever starting point was taken, the ultimate raw material would be sugar or starch. Perhaps Perkin was deterred by the economics of using alcohol which, though duty-free for approved purposes after denaturation, has yet remained relatively expensive in this country.

In 1912, alcohol was 2*s*. per gallon and butadiene would have cost about 7½*d*. per lb. As this had yet to be polymerised and processed the synthetic rubber would have been perhaps too costly as compared with the basic costs of producing natural rubber. Natural rubber had reached a scarcity value of 15*s*. per lb. as a consequence of plantation output lagging severely behind the demands of the world's rapidly expanding automobile industry. But, perhaps, Perkin was most deterred by the fact that, as he pointed out, an annual output of 80,000 tons of rubber would have required 100-120 million proof gallons of ethyl alcohol, a quantity which was double the output at that time of the distilleries of the United Kingdom and those of the United States, and about one-fifth of the total world's output of alcohol. These facts alone were sufficiently discouraging, but in addition there was no extensive and cheap agriculture in this country, such as existed on the European and American continents, which could be expanded to produce even a reasonable proportion of the quantities of potatoes or sugar-beet required for the fermentation.

### An Astonishing Decision

Whatever their final precise reasons were, the British workers turned from ethyl alcohol as a starting material to butyl alcohol. At first sight this would appear an astonishing decision since, as has been pointed out, butyl alcohol was little more than a laboratory curiosity, there being no manufacture beyond an occasional laboratory scale production. But Professor Fernbach of the Institute Pasteur in Paris had recently developed and patented a process by which butyl alcohol could be obtained from potato starch by the action of certain bacteria. Since the same objections applied to the use of starch for the manufacture of butyl alcohol as for ethyl alcohol, one can only conclude that the route was preferred because of its novelty, its potentialities and the possibility of covering the method by patents from the very initial step, namely, the fermentation.

Fitz, a bacteriologist, had first isolated an organism in 1876 which was capable of producing butyl alcohol from glycerol, and the essence of the Fernbach and Strange patent of 1913 was the use of a "butylic bacillus of the type of Fitz" which was capable of producing butyl alcohol from starch without previous conversion to simple sugars as is necessary in alcoholic fermentation. In 1912 Weizmann broke away from the group and continued investigations independently in Manchester, where he isolated an organism capable of fermenting starch, *without* previous conversion, to a mixture of butyl alcohol, acetone and ethyl alcohol, the first of these preponderating.



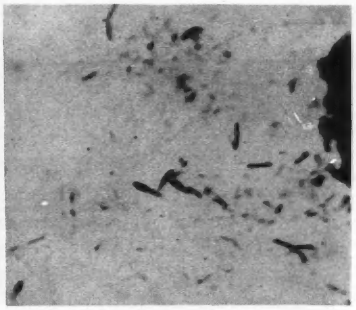


FIG. 9 (left)—*Clostridium aceto-butylicum*. Vegetative cells in a 24 hour-old culture. The organism has this appearance when it is actively fermenting. In these conditions it reproduces by fission, and chain formations may be seen in which mother and daughter cells have not yet separated. Magnification x 950. (*Photo-micrograph by courtesy of Dr. A. C. Thaysen*). FIG. 10 (right)—*Clostridium aceto-butylicum*. At the completion of fermentation the organism forms spores representing a resting stage in the life history which enables it to survive adverse conditions. Spores of this organism which can survive a controlled "heat-shock" give the highest yields of solvents. This remarkable photo-micrograph (reproduced by courtesy of Dr. A. Thaysen) shows to the left centre readily stainable plasma collecting at one end of the cells in the early stage of spore formation. In the centre of the field is a single fully-grown spore, which has hollow appearance. Magnification x 950.

### The Weizmann Process

This was the subject of a patent in his name in 1912. One important feature of his discovery was that the organism which could be obtained from soil gave the best and most consistent yields when subjected to "heat shock" under specified conditions which only the heat-resistant, high-yielding spores survived. A second important feature of the discovery was that the organism would not only ferment potato starch but, unlike Fernbach's bacillus, it would also ferment cereal starch. (An important point about using cereal starch is that, unlike potato starch, it contains sufficient nitrogenous nutrients and trace substances to make it unnecessary to add additional nutrients).

By the Weizmann process one bushel of corn yielded after fermentation and distillation 10-11 lbs. of solvents represented by 60% butyl alcohol, 30% acetone and 10% ethyl alcohol. In addition, for every 1 lb. of solvents there was also produced 1½ lb. of a mixed gas composed of carbon dioxide and hydrogen.

In the meantime Strange & Graham, Ltd., had erected in 1913 a factory at Rainham to work the Fernbach process. When the Great War broke out, it brought with it a great demand for acetone, needed for explosives manufacture and later as a solvent for preparing aeroplane "dope". With the loss of the dyestuffs industry to Germany during the previous 50 years Britain found herself with a small chemical industry with limited, if not negligible, resources. The bulk of the acetone obtainable at that time was made by the dry distillation of calcium acetate which, in its turn, was produced by the dry distillation of wood. This manufacture had been almost entirely confined to Germany and the Central European states and was now, of course, beyond the reach of the Allies. The only alternative was the Fernbach process, and Strange & Graham, Ltd. contracted with the British Government to supply the acetone. A factory was set up at King's Lynn, within easy reach of the potato fields of the Lincolnshire, Cambridge and Norfolk fenlands. Hopes were, however, not realised. The bacillus used proved somewhat inefficient and unreliable in large-scale operation and eventually a destructive fire brought the whole matter up for review.

Consideration was now given to the bacillus of Weizmann, the substrate for which, it will be remembered, was not restricted to potato starch. As a result of further research carried out by Weizmann at the Lister Institute, together with large-scale development at Nicholson's Distillery at Bromley-by-Bow, and later, at the R.N. Cordite Factory, Holton Heath, by Reilly, Thaysen and their co-workers, it was decided to adopt this organism for future developments, especially as it was becoming acutely apparent that every bushel of home-grown potatoes would be required for food in view of the serious development of U-boat warfare. It became clear that rather than import maize, which now emerged as the best alternative starting material, it would be preferable to set up the Weizmann process where the grain was grown, especially since the production of every 3 lb. of acetone required the importation of 56 lb. of maize.

As a first step two grain-alcohol distilleries at Toronto—the Gooderham and the Wort Distilleries—were converted to the Weizmann process. When U.S.A. entered the war, the Commercial and the Majestic distilleries at Terre Haute, Indiana, in the Corn Belt, were similarly adapted by the Allied War Board.

### Solvent for Nitrocellulose

At the end of the Great War the demand for acetone contracted to normal peace-time dimensions, and the Allied War Board was left to contemplate the huge stock of unwanted butyl alcohol which has been accumulated in great vats. This surplus seemed at first sight enough to deter anyone from operating the Weizmann process, since the possibilities of using it for the manufacture of synthetic rubber had receded. As one writer commented, bacteria work the same in war-time as in peace and, whatever quantity of acetone was produced, twice that quantity of undisposable butyl alcohol had to be accepted.

A dramatic change now came over the situation. Nitrocelluloses dissolved in amyl acetate were being rapidly developed as lacquers, but their use was restricted by the limited amount of amyl alcohol available from the ethyl alcohol fermentation for making the ester. But now it was found that the acetic ester of butyl alcohol was an excellent solvent for nitrocellulose. This discovery was to prove a major factor in making possible the mass production of automobiles. Hitherto car bodies had been finished with protective coats of oleoresinous varnishes which took a month to dry and harden; now, by using the butyl acetate-nitrocellulose lacquers, the solvent could be volatilised in 3 to 4 hours, resulting in the hard brilliant finish beloved of the car owner. Thus the process which had originally been developed in this country to produce butyl alcohol for the manufacture of synthetic rubber tyres for motor vehicles finished up by giving them their nitrocellulose lacquer finish.

This great new outlet gave the butyl alcohol-acetone fermentation a new significance, and the emphasis now became placed on the maximum output of butyl alcohol and not of acetone. The acetone and ethyl alcohol simultaneously formed could be easily disposed of. The Commercial Solvents Corporation was formed to take over the Terre Haute plants from the Allied War Board, world-wide rights were acquired in the Weizmann patents, and a new plant was later constructed at Peoria in the heart of America's Corn Belt.

The central feature of the fermentation is that it is highly anætobic—to obtain maximum yields no trace of air may be admitted to the fermenting vessel. The fermenters are therefore totally enclosed (except for ducts to lead away the large volume of gases evolved) and the grain mash and nutrients may be sterilised *in situ* prior to inoculation by a culture of the bacillus. Fermentation is completed in 3 to 4 days, and then the contents of the fermenters are passed to continuous stills, where the volatile components are separated by fractional distillation.

During the intervening years the process has undergone some changes, of which two developments are of fundamental importance. Firstly, it is to be understood that for every 1 lb. of mixed solvents produced by this process, 1½ lb. of mixed gases—carbon dioxide and hydrogen—are given off. These gases are now collected and used for the synthesis of methyl alcohol (one of the important uses of which is in denaturing ethyl alcohol to give methylated spirits). The second important development has been the isolation of new strains of *Clostridium aceto-butylicum*, which will ferment molasses. The economic importance of such a development is precisely that noted in the case of the ethyl alcohol fermentation, namely, that

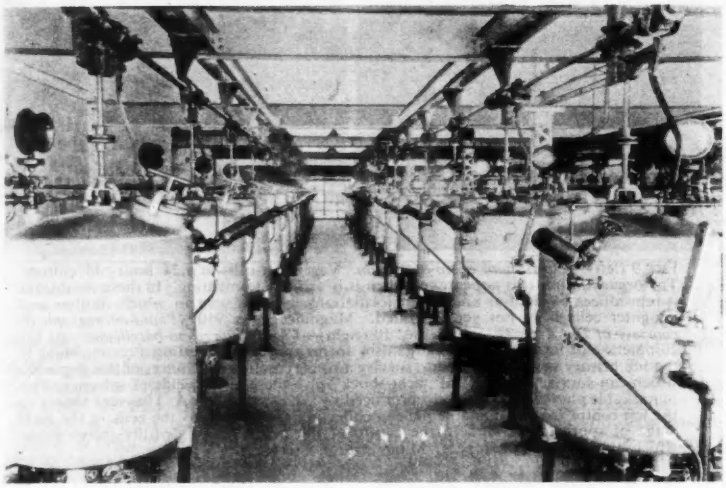


FIG. 11—Culture tanks for *Clostridum aceto-butylicum* in which the inoculum for the fermenters, shown in Figs. 12 and 13, is prepared. These culture tanks are themselves "started" with a smaller quantity of inoculum prepared in glass flasks in the laboratory from the "master" culture. (*Photograph by courtesy of "Industrial and Engineering Chemistry."*)

the raw material for the fermentation is now derived from the waste product of another industry, so eliminating competition with the foodstuffs and feeding-stuffs industry for starch-containing commodities. At the same time the yield of butyl alcohol has been increased relative to the proportions of acetone and ethyl alcohol formed. At the outbreak of the present war the fermentation was worked exclusively from molasses; but after serious losses to the tanker fleets, the industry in the United States had to revert to the original Weizmann process, using maize.

In 1935 Commercial Solvents (Great Britain), Ltd., established a distillery at Bromborough on Merseyside for the exploitation of the butanol-acetone-from-molasses process. Thus, after being exiled across the Atlantic for 20 years, the butyl alcohol-acetone fermentation process returned, somewhat metamorphosed, to the country of its birth.

### Development of Synthetic Rubber

It is now of interest to return to the British research group who set themselves the problem of making synthetic rubber. We have seen that, while their main interest and effort proved abortive, an unforeseen development occurred which has deeply effected the amenities of our civilisation. The quest for synthetic rubber has never since been pursued far in this country, mainly due to the low price of natural rubber the cultivation of which was largely controlled by the British Empire. On the other hand, the problem has been actively pursued both in Russia and in Germany, the pioneer work being initiated in these two countries respectively by Ostromislensky and Harries. In each country ethyl alcohol has been used as the starting material, the possibilities of which, it has been seen, Perkin considered but did not follow. The stages in the route are as follows: ethyl alcohol → acetaldehyde → aldol → butylene glycol → butadiene; the butadiene is polymerised with styrene to give the rubber-like co-polymer known as Buna S (which type represents nearly 90% of the U.S. output of synthetic rubber in 1944). The raw material has been potatoes, which are grown very extensively in the continental countries and hence provide a cheap source of starch.

The potato starch is first hydrolysed to simple sugars by pressure treatment with acid or by mashing with malt after gelatinisation. The wort thus produced is fermented by yeast, after the addition of nitrogenous and phosphatic nutrients, and the alcohol is subsequently distilled off. About 2.8 tons of ethyl alcohol are required to produce 1¼ tons of butadiene and, eventually, 1 ton of synthetic rubber. Germany commenced large scale production of synthetic rubber in 1928; the facts regarding the Russian industry are obscure.

The loss in 1941 of Malaya and the Dutch East Indies was a most serious blow to the United Nations, for both the British Empire and U.S.A. were dependent to the extent of over 90% upon these regions for the rubber which plays so fundamental a role in modern mechanised warfare. It was quickly realised that synthetic rubber must be made in vast quantities and without delay. Such was her geographical position with regard to raw materials, and such was her man-power problem, that it was apparent that Great Britain could not undertake the venture. It was therefore left to America to mobolise her resources to make good the deficiency.

### Progress since Pearl Harbour

It is proper that the technical and administrative effort which has been made across the Atlantic, and which has saved the United Nations from disaster, should be appreciated to the full. It was apparent that manufacture from ethyl alcohol could be most rapidly developed since, as has been shown, the details had been well worked out on the continent over the past twenty years. There were two principal methods available by which ethyl alcohol could be produced in U.S.A., the first being fermentation and the second being by synthesis via ethylene derived from petroleum. The latter method had been developed on an industrial scale between the wars, but the existing capacity was quite inadequate for the new demand. The choice finally turned upon plant—fabricating capacity. In any case new plant buildings and equipment had to be manufactured for the ethyl alcohol-synthetic rubber stages. If ethyl alcohol were to be obtained from petroleum, the plant required for expanding the existing synthetic alcohol industry would have been a serious competitor for the plant—fabricating capacity, and also for supplies of certain alloys, already scarce. On the other hand if ethyl alcohol were obtained by fermentation every existing alcohol distillery in the country, industrial or potable, could be mobilised in the effort. This latter plan was the one adopted.

It will be recalled that after the Japanese attack on Pearl Harbour the Germans concentrated upon the sinking of tankers in the Atlantic and the Carribean Sea and they attained a considerable measure of success before protective measures could be taken. As a consequence, molasses tankers had to be diverted to the carriage of petrol and oil, and it became almost impossible to shift molasses from the sugar-producing islands of the West Indies to the molasses distilleries of the eastern seaboard of the United States. Since, in peace-time, 75% of the alcohol produced in U.S.A. was derived from molasses fermentation the seriousness of the position in view of the imminent war-time expansion can be imagined.

Such was the urgency of the situation that raw sugar was, at first, brought in for fermentation from Cuba and Porto Rico, and stocks of sugar within the U.S.A. were drawn upon to the point at which supplies to a civilian population, which consumes more sugar per head than any other nation, began to be affected, with political repercussions. Since sugar could be carried in dry bottoms this saved tanker capacity in a very critical period. In the meantime, every beverage distillery in the Corn Belt was turned over to industrial alcohol production, and where the still design was inadequate to produce 95% alcohol the "high-wines" (or weak-distilled spirits) were taken to other distilleries which had facilities for re-distillation to full strength.

The magnitude of the effort involved may be judged from the fact that the output from former beverage distilleries alone rose from 53.9 million U.S. wine gallons in 1942 to 152.4 million gallons in

1943, representing an increase to 40.0%, in round figures, of the total output of ethyl alcohol from all sources in the U.S.A. The importance of the contribution of the former beverage distilling industry may be, judged by reference back to Table II (DISCOVERY, November, p. 337). The truly phenomenal expansion of output which has been achieved in the interests of the United Nations synthetic rubber programme reveals a striking flexibility of administrative and technical outlook. To take a single example: in *one year* following the torpedoing of the last cargo of molasses in May 1942, one New England molasses alcohol distillery adapted itself to the use of various raw materials in the following sequence: molasses—grain—granular wheat flour—molasses.

The projected butadiene plants were coming into full operation about the middle of 1943, and towards the end of that year consumption of fermentation alcohol was reaching the enormous figure of 27,000,000 gallons per month. Fifteen tankers have been made especially available for transporting molasses from the Carribean islands to the Gulf and Eastern seaboards. With the improved shipping position the Americans hope to persuade Great Britain to re-open her distilleries and to receive molasses again instead of Lease-Lend alcohol, which reached a peak of 68 million gallons in 1943.

It is not surprising that, the production of beverage alcohol having temporarily ceased in U.S.A., there has been an attempt to revive the "bootlegging" of the prohibition period, the illicit spirits being derived from the West Indian islands where the situation is interesting.

### A Surplus of Molasses

With the shipping losses of 1941-42 it became impossible to shift the molasses which are the waste product of the staple industry of the region. Consequently there was an enormous increase in stocks. A similar situation arose on the world trade depression of the early 1930's, when the excessive accumulation was relieved by emptying the molasses tankers in mid-ocean and such molasses as were sold were passing at the low price of £1 per ton. In this war tankers have not been available to perform this elementary, deplorable but (unfortunately) necessary service and, no doubt, the authorities foresaw that, as the shipping situation improved, the fermentation industries would call for every ton of molasses available. Great quantities of molasses have, therefore, been pumped into pits and this embarrassing accumulation was estimated to have reached by 1943 well over 2,000,000 tons which, via fermentation ethyl alcohol and butadiene, would be equivalent to over 100,000 tons of synthetic rubber.

The position in Cuba is especially interesting. Rum has long been made there by fermentation of sugar cane juice or, latterly, of cane-sugar molasses and there is a profitable export trade with the American mainland. In addition, there has grown up a production of alcohol over and above the potable alcohol output, and this has been mainly used for admixture with imported petrol as fuel for internal combustion engines in the island. As the tanker position has improved, the U.S. Government has opened negotiations with the Cuban Government for the Cuban molasses output for feeding the Gulf and East Coast distilleries with a view to reducing the encroachment of the fermentation industry upon the grain which is increasingly required for food. The negotiations have been difficult and there has been talk of economic sanctions being applied.

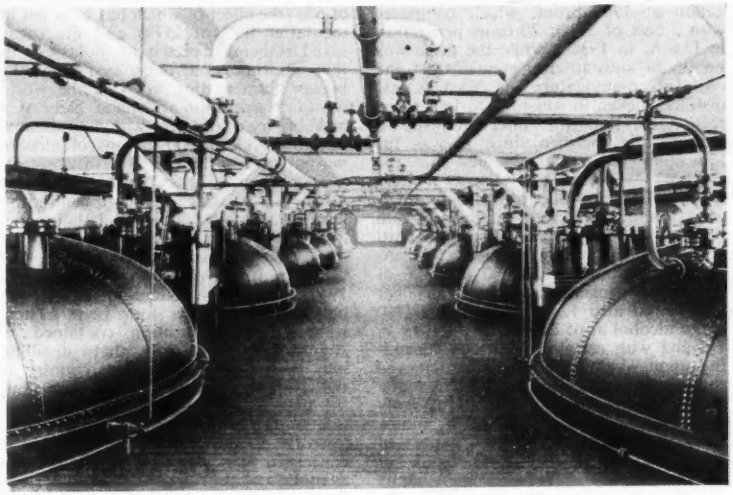


FIG. 12—Butyl alcohol/acetone fermenting tanks, top view. Note that since fermentation is anaerobic, the tanks are totally enclosed except for the duct carrying away the carbon dioxide-hydrogen gas mixture produced in the fermentation. (*Photograph by courtesy of "Industrial and Engineering Chemistry."*)

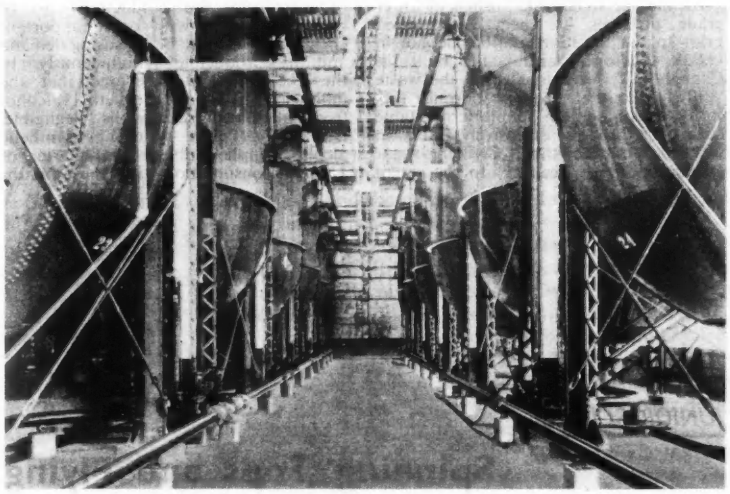


FIG. 13.—Bottom view of the 50,000 gallon fermenting vessels shown in Fig. 12. (*By courtesy of "Industrial and Engineering Chemistry."*)

Cuba represented that, if she ceases to ferment molasses, she will have no alcohol to add to her petrol and consequently increased quantities of petrol must be imported from Mexico; in the second place she represented that it is illogical to take away her raw material, which would close down the fermentation alcohol industry in a country where unemployment is rife, in order to ferment the molasses to alcohol in a country where there is a great scarcity of labour. Cuba therefore offered the U.S.A. 50,000,000 gallons of "high wines", equivalent to two-thirds of the output of Cuban distilleries, at 62 cents per

gallon at 190° proof, which compares with a cost of about 20 cents per gallon in U.S.A. in 1938. While the price was no doubt substantially greater than the cost of manufacture at East Coast distilleries even in war-time, it had to be recognised that the offer involved a considerable sacrifice since it was far less than could be obtained for the alcohol exported to U.S.A. (where spiritous liquor production has temporarily ceased) and elsewhere in the form of rum or gin. The arrangement finally reached after lengthy negotiations was that U.S.A. would purchase 65,000,000 gallons of blackstrap molasses at 13.6 cents per gallon and also 12,500,000 gallons 190 proof alcohol at 65 cents per gallon f.o.b. Havana with certain conditions depending upon whether or not Cuba achieved these outputs. This would leave Cuba with molasses equivalent to roughly 20,000,000 gallons of alcohol for motor fuel, and she agrees to limit export of rum and gin to her 1943 figure of 14,300,000 proof gallons. Thus a happy compromise has been achieved; the United Nations get the molasses and alcohol they require without penalising Cuba's important industry, or encouraging "bootlegging".

Meanwhile 18,000,000 bushels of lower grade potatoes are being dehydrated prior to use for fermentation alcohol in U.S.A. Factories are being built in Canada to ferment to alcohol the waste "sulphite-liquors" from wood-pulp factories, which contain simple fermentable sugars—a process extensively used in Sweden in peace-time. Civilian sugar consumption has been cut to the extent of 6% (the effect of which has been felt in the latter half of 1944) and the sugar saved is being directed to molasses. In the meantime what is claimed to be the biggest fermentation plant in the world went into operation at Omaha, Nebraska, in February of this year with an estimated output of 17,500,000 gallons of alcohol per annum from grain.

Such then is the colossal endeavour of the U.S.A. which has been centred on fermentation ethyl alcohol. It is practically certain that the industry in Britain has been in a state of at least *partial* suspense during part of the period since 1940, although the situation may clearly have fluctuated over four years. There is now the implication contained in American information that distilling may be fully resumed in this country as the shipping position improves; but the man-power position may well be a limiting factor in what is attainable.

So far as the future of ethyl alcohol is concerned, it is safe to say that, so long as molasses are available as an otherwise useless by-product, fermentation alcohol will continue to be produced. However, the field will have to be increasingly shared with ethyl alcohol synthesized from ethylene produced in the "cracking" of petroleum, the production cost of which is shared with other important chemicals which are in increasing demand and are producible simultaneously. In the U.S.A. it is considered that the difference in the cost of ethyl alcohol from the two sources is negligible, nad it has been seen that synthetic alcohol supplied about one quarter of U.S.A. consumption in the months previous to her entry into the present war.

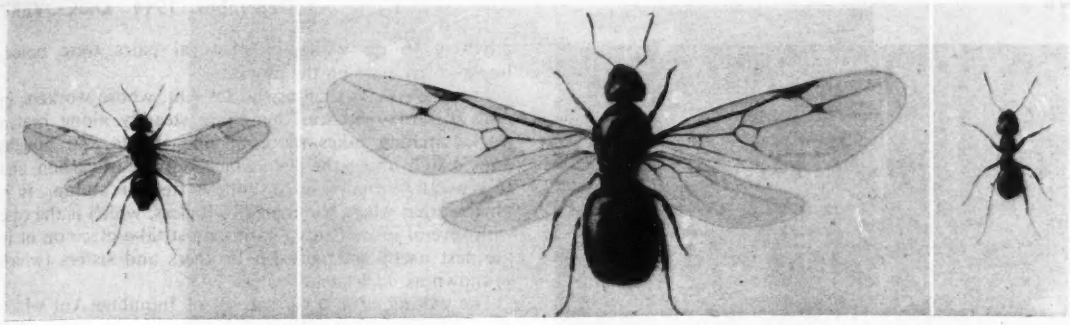
It is not easy to foresee the precise position in this country after the war. Ethyl alcohol has always been relatively dearer here than in other countries. In general, such circumstances induce large consumers to manufacture their own material and it is important to note that one large manufacturer of artificial silk —who, it appears, may also become interested in plastics and synthetic rubber —has, since the war began, established a plant in the Midlands capable of the manufacture of synthetic ethyl alcohol, among other products, from petroleum crudes. Whether a situation will arise here comparable to that in the U.S.A. remains to be seen. It has to be remembered that, like molasses, petroleum crudes have to be imported into this country and so the latter show no advantage in this particular respect. Moreover, molasses, together with the concomitantly produced raw sugar, is produced in the Colonies, and is an important item in their prosperity and in the availability of cheap sugar to this country. Further, while the synthetic rubbers will ultimately have an important place commensurate with their special properties, any very large expansion of ethyl alcohol production for this purpose is unlikely in view of our extensive colonial interests in the natural rubber plantations. There are, however, many subtle factors involved, some of which will not be wholly devoid of political implications. The situation will remain in a state of flux long after the last shot has been fired in the present war.

*[To be concluded*

*JUNIOR SCIENCE*

# Spinning Tops and Flying Bombs

LAST month I told you something about inertia. You remember that the inertia of a railway train has to be overcome to set it in motion and that when the train travels at a steady speed its inertia tries to *keep* it in motion. In fact an effort has to be made—that means work has to be done—to stop the train. All these things are so familiar to us that we generally do not stop to think about them. But there is another phenomenon, equally familiar to us, which we are often at a loss to explain; that is the action of a spinning top. Just watch a child who sees a spinning top for the first time. He will usually, after the top has run down, pick it up and try to stand it again on its tip. Of course, he never succeeds. Now, why is it that the top will only stand up when it is spinning? The moving train provides the explanation. The inertia of the top tries to keep it in motion just in the same way as the inertia of the train keeps the train running. The inertia of a moving train, car or bicycle not only maintains its motion but also its *direction* of motion. You know that an effort has to be made not only to stop a moving body but also to change its direction. In the spinning top every atom describes an orbit around the axis of the top and all these orbits are parallel. That means that the spinning top stands up because the inertia of all the atoms tends to keep them in their original direction of movement. Only when finally the spinning motion is slowed down by friction is the gravitational attraction of the earth strong enough to tip the top over. If you try to upset a spinning top by gently tapping it, you can feel the resistance offered to your action by the force of inertia. A motor cycle (the mass of the wheels of your bicycle is too small to have an appreciable effect) is one of the many examples of how we make use of the "stability" of a rotating mass. It is the inertia of the spinning wheels which gives the motor cycle its great stability. Other applications of this principle are the large stabilising tops which have been built into liners to stop them rolling in the waves and the "automatic pilot" in which a small spinning top governs the controls of a plane which is to be kept on a steady course. The flying bomb, too, is navigated by such a "gyro". K.M.



Male, female and worker of the Small Black Ant.—*Acanthomyrps* (*Donisthorpea*) *niger*.

# Flying Ants

HORACE DONISTHORPE, F.Z.S., F.R.E.S. Lond.

EVERY summer winged ants are sent to the Natural History Museum, with a note from the various senders explaining that, to their great astonishment, they had seen swarms of winged ants rising from the ground; that numbers of these insects were everywhere; that they had never seen such a spectacle before, and could we give any explanation, name the species, and say where they had sprung from, etc., etc. Small paragraphs and letters from correspondents appear in the newspapers on the subject; often the ants have been said to invade houses, interrupt road traffic, stop trains, and so on.

And yet this simple phenomena takes place every year. It has always done so, and always will as long as there are male and female ants in the world. In a word, it is simply the marriage, or nuptial flight of these insects. It takes different forms in different species according to the habits or habitats of the ant in question. The most ordinary form, and that usually observed by such writers as have been mentioned above, is that of the Small Black Ant, one of the commonest species in Europe. Their ancestors are found in the Baltic amber, and are almost indistinguishable from the form of the present day.

The following is a brief description of a marriage flight of this ant observed on August 9 at Folkestone some years ago. A large colony occurred in one of the pillars of a gateway to a house, the ants entering the masonry by a hole in the mortar at the base of the pillar. At five o'clock in the afternoon the workers were much excited running all over the pavement, and up and down the pillar; a few winged ants were out, going in and out of the entrance to the nest. At six o'clock thousands of males and winged females appeared, emerging from the hole, swarming all over the pillar, and climbing to its top and on to the railings and shrubs in the garden. A few couples were observed in copula, and these flew away together, but most of the winged ants flew off separately, rising straight into the air and going up so high that they were lost to sight. The workers helped some of them to start, tapping them with their antennae, and pushing them to the top of the pillar. By 6.25 p.m. nearly every winged ant had disappeared, and a few females were already on the ground having lost their wings.

With slight variations and according to the situation of the nest, etc., this is the usual procedure of these and other nearly related ants. It is undoubtedly a fact that the ants are affected by some atmospheric influence which may extend over a large area. Flights have been noticed in counties round London, and also at a distance—even in France—and these have occurred on the same day and at the same time.

Vast numbers of males and females of this ant are often produced. In September, 1855, immense clouds were observed passing over the town of Dover towards the sea. Subsequently a line of their floating bodies, about a yard broad, was observed along the beach, extending from the town for at least a mile towards St. Margarets.

The male of this ant is considerably smaller than the female, and this enables her to carry him in the air during the marriage flight. In the so-called "Red-ants" (species of *Myrmica*) the procedure is very different. The marriage flight, which takes place in the autumn, commences in the air, but as soon as the couples are united they fall to the ground together, because the female is unable to carry the male when on the wing; the latter is as large as she is herself. When these ants fall down together on to a greenhouse roof or on to the leaves of trees, the pattering noise thus caused leads one to think that it has commenced to rain. The winged sexes sometimes occur in such numbers as to give the impression of a cloud of smoke in the air. It was probably a swarm of these ants which in 1866 caused the people of Coburg to think that the tower of the church of St. Maurice was on fire. Seen at a distance of thirty paces the effect of a swarm of these ants rising and falling over a small tree assumes the appearance of curling smoke. At forty paces the tree appears to be on fire, but from fifty paces away the smoke seems to have nearly vanished into thin air.

The winged sexes of the Wood Ant, which constructs

The nest of the Wood Ant

the well-known hillocks of pine-needles in pine woods, appear much earlier than those of the species we have just dealt with. I have observed them in this country at large and away from their nests as early as April 17, but the marriage flights take place from June onwards. So far as I know, no one, other than the writer, has actually seen a marriage flight of this ant; nor is there any record of the actual mating of the sexes, other than the one to be now mentioned. On June 15, 1911, I actually witnessed at Aviemore the coupling of the sexes in the middle of the afternoon. A number of males and females of the Wood Ant were seen flying about in a timber yard, running about on a large mound of sawdust in the hot sunshine, and flying off and settling on it; the males appeared to rise more easily than the females. Mating took place on the mound: I never saw a single pair together in the air. Sometimes a female would rise and fly straight up into the air, whilst others ran about on the mound, and occasionally when a male had found a female, the latter would refuse to have anything to do with him. Several pairs were noted, however, to mate on the mound.

In some species such as the Jet Ant, whose workers, in long files, may be seen marching steadily along beaten tracks, mating takes place on the shoots and boughs immediately above the nest, which is made of carbon, and is generally situated in a hollow tree or stump. It is obvious that where the male is wingless, which is the case with several of our ants, mating must take place on or in the nest itself, and between brothers and sisters (which is known as *adelphogamy*).

The mating of a small species of Inquiline Ant which lives in the nests of the large Wood Ant has been described as follows. After a cold night, the sun remained behind a mass of clouds at about 9 a.m., when I saw dozens of these small ants of all three phases, but mostly males, running hither and thither over the small twigs and other débris forming the outer covering of a Wood Ant's nest. The males moved very quickly, with antennæ feverishly vibrating, and were so amorous that they often seized workers and attempted to mate with them. The winged females present were soon supplied with partners, and the supernumerary males continued to hurry about over and among the little sticks of the nest. Then the sun suddenly emerged from the clouds and as if by magic, all the little ants disappeared into the nest.

As a last example of this, the most exciting and thrilling event in the life of an ant, let us take the marriage flight of a small species which lives in the coffee-fields of South America. In this case much damage is caused to the coffee plants, as will be seen when the habits of these ants are disclosed. They live at the roots of shrubs and bushes, and keep scale-insects in their nests, obtaining a sweet secretion from these pests. These ants are injurious to cultivated plants, for they help to disseminate the scales. The worker ants maintain much solicitude for them moving them about on the roots, and always carrying them between their legs, right side up, with the head forward. When the female ant leaves the nest for her marriage flight, she carries with her in her jaws, a young female root-scale insect. After the marriage flight, and when she has shed her wings, she proceeds to found a colony at the roots of a new, healthy coffee plant. The first thing she does is to place the scale-insect on the roots of the plant. The scale-insects cause considerable injury to the coffee plantations, for not only do they suck the sap of the plants—the loss of sap alone weakens the vitality of the trees—but they also infect them with pathogenic organisms. As the scale-insects are extremely prolific and as very many female ants are produced in the nests which are often very numerous in the coffee plantations, it will be seen how real a danger these ants may become.

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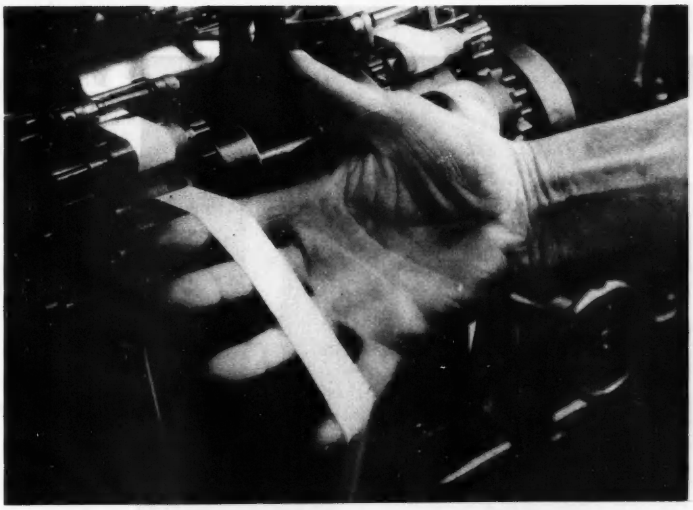
Without exception, all the really useful inventions I have come across have taken the form of the application of experience, or research, or both, to some particular need. The "brain wave in the bath" type of invention, so beloved of novelists and the popular press, is a thing I have never met in real life, nor have I yet seen any really useful contribution to the art by a man or woman untrained or unversed in it. In my experience, the successful inventor is he who applies his knowledge, whether it be derived from practical experience or from academic research, to the fulfilment of some need in the right way and at the right time.—HARRY R. RICARDO, *in his presidential address to the Institution of Mechanical Engineers.*



A close-up of glass tape emerging from the loom.

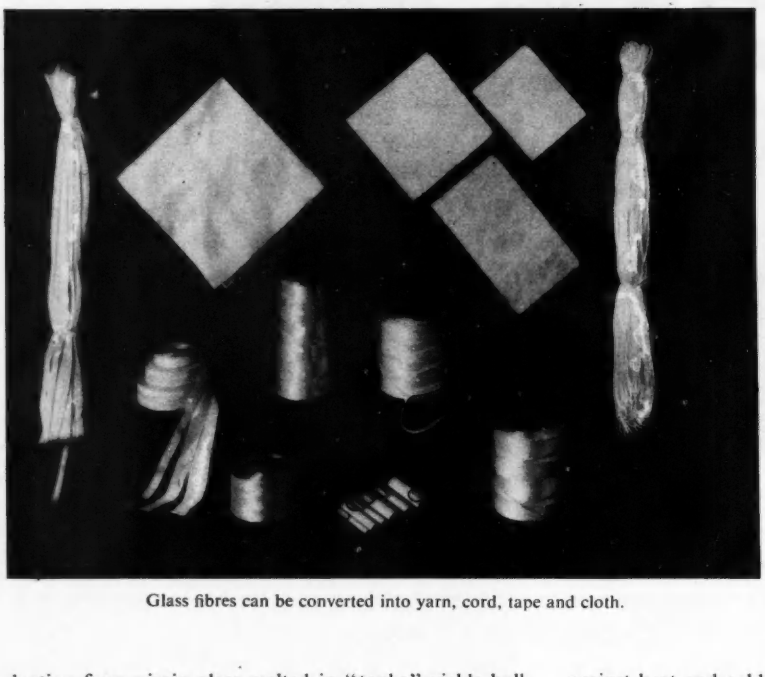
# Glass Wool and Silk

M. SCHOFIELD, M.A., B.Sc.

AMONG a number of artificial fibres now seeking to become established in the industrial field (in which rayon has been established so long), "glass wool" or "glass silk" is one of the strangest. While all other fibres are protein or carbohydrate in nature and derived from natural organic raw materials, fibre glass is the only artificial mineral type, corresponding to the natural mineral silicate asbestos which also appears in textiles for special purposes. In its early years of commercial development glass wool seemed to be progressing towards an alternative material to asbestos: that is, for heat insulation and corrosion-resisting purposes, as in filtering pads for example. But new methods of manufacture brought fibres so fine and flexible as to permit the use of glass silk in such diverse commodities as lampshades, brocades, damasks, bedspreads and even neckties.

As with so many other commodities the first beginnings of fibre glass must be credited to the ancient Egyptians. They decorated their vases, jugs and urns with thin glass strands, these being coarse and uneven in comparison with to-day's controlled standards yet nevertheless involving the first method of preparation used in commerce, viz., drawing by hand. In more modern days glass fibres first appeared during the last war when German technicians at Dusseldorf sought to replace losses of imported asbestos by drawing what was a coarse brittle fibre suitable enough for making thermal insulation mattresses and for use in air filters. Molten glass was simply spun from the furnace and wound at first by hand on a revolving wheel—hence the name "spun glass"—and later on mechanical drums. This idea had also been demonstrated at American exhibitions when the spinning of glass was merely a novelty. Fine threads from glass rods fused in portable furnaces or in an intense flame were wound by hand and made into lampshades which fetched a good price as a novelty. Any fibre thus produced was nothing more than a long sharp-pointed glass rod with all the expected disadvantages, such as brittleness; the material was difficult to handle since broken fibres penetrated the skin causing pronounced irritation, and were dangerous if inhaled. Moreover, any lack of control in melting the glass before spinning caused air bubbles with consequent breaking of the spun fibre. Earlier methods used in the factory failed also to give uniformity since the orifices in the furnaces forming the spinnerets were constructed in refractories which failed to withstand the continued attack of molten glass. Only in the last eleven years or so has it become possible to make fibre glass continuously, automatically and economically enough for it to become established on the market and meet competition from asbestos.

Great improvements came with the adoption of orifices constructed in platinum-noble metal alloys for the spinning process (a lesson which might well have been learned from the rayon industry where such expensive materials alone resisted corrosion). A second improvement in the production of staple fibre was the use of high-pressure steam or air jets to tear apart the fine stream of molten glass and thus yield a mesh of interlocking, cylindrical and smooth fibres which were carried forward on travelling belts as they fell like snow from the "blasting" process. Raw materials of high-grade silica sand and lime-soda bases (except in the preparation of fibre glass for the electrical insulation trades) are melted together. Two different processes in glass fibre manufacture must be distinguished: firstly, the production of a staple fibre by use of high-pressure jets, and secondly, the preparation of continuous filaments. In some instances a direct pro-



Glass fibres can be converted into yarn, cord, tape and cloth.

duction from virgin glass melted in "tanks" yields bulk "glass wool" for use in blankets, and for chopping up into a shorter granulated glass wool for packing purposes. In others, especially when continuous fibre production is aimed at or when high-grade staple fibre is to be the raw material for yarns, cloths, braids and tapes, the glass is first converted into glass marbles so that a rigorous inspection of such intermediate forms may be ensured. A mass of interlaced fibres is then spun from the re-melted glass and the "sliver" of eleven fibres gathered from the operation passes next to the textile machines. The continuous process yields a gossamer-like fibre, so fine that it can scarcely be seen, and so light that it is blown away by a breath; it can be handled with freedom from penetration of the skin because of its resilience. Such fibres from over a hundred orifices in the electric furnace are drawn together without twist using the spindle of a drawing machine working at a mile a minute. Filaments are lubricated with oil as in the case of a textile fibre before spinning, while a starchy protective layer is also added at times before the fibre is passed to a process very like worsted spinning. (The oil is afterwards more readily removed than in the case of cotton since it cannot penetrate the fibre). Each filament is of rather less than one forty-thousandth of an inch in thickness and forms strands 25 thousandths of an inch in diameter, such strands passing from the drawing machine to the twisting machine to be converted into yarn.

This continuous drawing by winders taking the fibre at the rate of a mile a minute yields a product of exceptional characteristics when compared with any other textile fibre. Whereas asbestos has to be taken in the grades provided by natural sources over which no control or modification can be exerted, glass fibre is simply what man makes it. It is of high tensile strength (up to two million lb. per square inch); it is flexible and not broken too easily, provided the fibres are not permitted to scratch against each other during production; it is not hollow like natural fibres, but is of solid glass with all the physical and corrosion-resisting properties of glass, being inert, and withstanding higher temperatures than other textiles, proof against mildew, rot and vermin. (The rat, a consumer of man's commodities, an uninvited guest costing the warehouse owner an average of eight shillings per annum per head, fails to survive a diet of glass!)

Glass fibres in a mesh enclosing air constitute a highly efficient insulator for heat just as is snow with its air "pockets". Ships, trains, aircraft, boilers, refrigerators and—in the United States—everyday domestic equipment, all have their place for glass wool either laid on in mattress form or bonded with magnesia. Insulation against heat and cold is attained in some cases by use of staple fibre blankets, and by hand-packing of glass wool into corners where shaped insulators do not penetrate. Blankets have a wire-mesh backing and are made to the required size and thickness. Granulated wool is also used, in the form of small pellets or nodules, for packing into small gaps or spaces, while backed pads or "bats" are made for the insulation of ovens, pipes and other objects too small for the blanket method of insulation. Electrically-heated diving suits for the United States Navy have been constructed with glass insulation.

For insulating electric cables, coils, windings of motors and transformers, insulation cloths and tapes of all grades and thicknesses are made. For this field of application a special alkali-free glass is prepared, that is, one which is free from soda and potash; otherwise under humid conditions there would be a tendency to absorb moisture with a consequent release of free ions leading to a breakdown of electrical properties. Varnished glass fabrics, varnished glass fabric boards of high electrical insulating value and mechanical strength, materials in which mica has been bonded: such are examples of applications of glass fibre in the electrical industry.

There are also glass porous mats built up from interlaced staple fibres for holding the active paste in the plates of electrical accumulators, the porosity being essential so as to allow the free flowing of acid to the plates. Glass in such accumulators and in the anode bags used in electrolytic plants possesses the supreme advantage of being resistant towards not only acids but the majority of chemical agents. Such resistance towards all corrosive agents except hydrofluoric acid and boiling alkalis explains its use (and possible future uses) in the chemical industries. For a considerable period glass wool has been

known in the chemical laboratory as an alternative often superior to asbestos for filtering both liquids and gases. In industry both in fume collectors and in air filters such an application has proved fruitful, particularly in the United States. Air conditioning of public buildings and factories has brought a considerable demand for various sizes and types of glass-fibre filters for removing dirt and soot, the fibre being in the form of compressed mats faced with stamped metal grills, the intake face being of coarse fibre and the discharge face of fine fibre, while a layer of oil or adhesive like tricresyl phosphate (which has good wetting power and is non-inflammable) causes the dust particles to adhere.

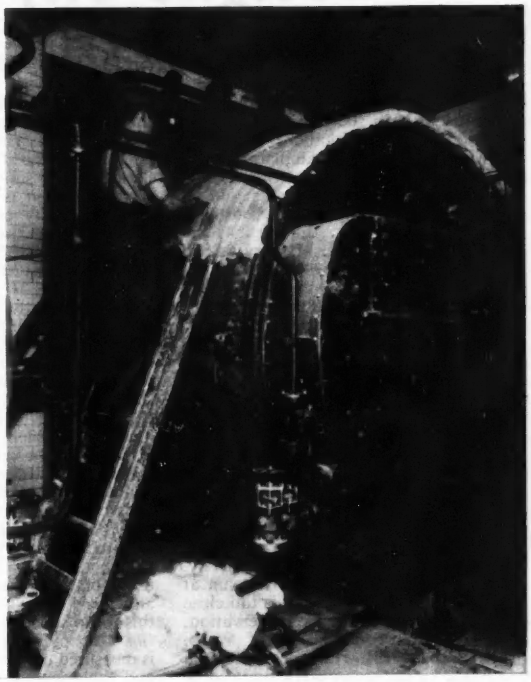
Sound absorption represents yet another outlet for glass fibres which will increase in the future. Glass wool free from attack by vermin, moulds and fungi, and capable of resisting moderate heat is obviously superior to cork, wood fibre, felt and the other organic materials used for sound insulation, and the United States has not been slow in adopting it in trains, auditoriums and planes. In the motor car trade of the United Kingdom fibre glass has been used for some years in motor car silencers; these consist of a straight perforated tube surrounded by an outer casing in which the glass wool is packed, the whole silencer having no baffle yet being efficient.

## Textiles from Glass

It is when one turns to glass textiles and to the possibility of glass fabrics for dress materials that novelty appears. The idea of glass fabrics is not so surprising when one considers that nylon and other plastics are becoming prominent in this direction, and that glass is the oldest of plastics (if one defines a plastic as being any material which at some stage in its manufacture was in a plastic state, viz. capable of flowing or being pressed into a mould). With artificial silk of both the viscose and acetate types so well established, the appearance of a new artificial textile fibre is of interest if it shows superiority in any particular direction. Glass silk satins and brocades woven on jacquard looms are so heat-resistant and fireproof that, if Miss 1944 deliberately leaves a lighted match or cigarette to burn on such fabrics, there can be no danger of the dress material catching alight. The only other comparable fireproof material turned into fabrics is asbestos—a dull, drab material in contrast to the striking silky appearance of glass textiles. Moreover, glass materials can now be dyed in a number of striking colours, such "staining" of a fibre which is solid and not hollow being achieved as a result of the endeavours of Glasgow chemists.

The dyeing process protected by British Patent 559,329 enables the glass in the form of filament, yarn or fabric to be dyed by methods normally used in the textile industry. The "lake"—the insoluble, water-fast colour formed of a dye plus mordant—is deposited on the outside of the solid glass filament instead of the inner hollow filament of cotton and wool.

Fifty years ago this latest use of glass in fabrics was hinted at when an American actress saw spun glass being made at an exhibition and ordered a dress length from it —the price was 300 dollars! A Spanish princess copied the idea with both a dress and a parasol. At first difficulty was experienced because of the prejudice against anything so novel. Cinderella had her glass slippers, but that was



Lagging the heating boiler of a London hotel. The glass wool is kept in position by wire netting, which also forms a key for the finishing coat of hard-setting cement.

in fiction. There was difficulty in finding a seamstress who would make up such dresses, for dressmakers refused to use their hands, needles or even scissors on a material which could not be creased without breaking and against the ends of which hands and skin had to be protected with a strong lining of silk. The early forms, lacking fineness and resilience, certainly merited such antipathy. An early expert writing on the coming craze remarked, "It is not to be regretted that this fashion for fabrics has neither extended nor survived, since it was certainly liable to produce serious injury to health . . . while the atmosphere of a ball-room in which several such dresses worn would be contaminated". Yet in this country the glass industry was not to be denied the opportunity afforded when the head of the Glass Technology Department at Sheffield married a teacher of glass engraving at Edinburgh University. As a tribute to the accomplishments of Professor Turner his bride was provided with a dress which demonstrated "the versatility of glass in its plastic form", the fabrics being made by Fibre Glass, Ltd., of Glasgow and sent to another Glasgow firm where a wedding gown, hat, shoes and handbag were successfully made. Now the new fibres of high resiliency and capable of being handled without injury suggest a future which America has already foreseen. Lampshades, neckties, brocades and satins of every tint are offered. The price is rather high and there is some tendency to crease in wear. But these drawbacks may yet be eliminated and glass textiles and curtains prove as popular in a post-war world as sound insulation be means of glass will certainly do in post-war houses.

# Night Sky in January

M. DAVIDSON, D.Sc., F.R.A.S.

*The Moon.*—New moon occurs on January 14d. 05h. 06m. U.T., and full moon on January 26d. 06h. 41m. The following conjunctions take place:

January

| | | | |
|---|---|---|---|
| 4d. 20h. | Jupiter in conjunction with the moon, | Jupiter | 4 S. |
| 12d. 08h. | Mercury ,, | Mercury | 0.2S. |
| 12d. 21h. | Mars ,, | Mars | 2 S. |
| 17d. 14h. | Venus ,, | Venus | 4 N. |
| 25d. 18h. | Saturn ,, | Saturn | 0.5N. |

In addition to the above conjunctions, Mercury is in conjunction with Mars on January 26d. 15h., Mercury being 0°.4N.

*The Planets.*—Mercury rises 1½ hours before the sun at the beginning and middle of the month, and about 36 minutes before the sun at the end of the month. The planet is stationary on January 2, and reaches its greatest westerly elongation on January 13. Venus can be seen in the evening hours; she sets at 19h. 51m., 20h. 29m. and 21h. 08m. at the beginning, middle and end of the month respectively. Mars rises 45 minutes before the sun at the beginning of January, but is too close to the sun for favourable observation. Jupiter, in the constellation of Virgo, rises at 23h. and 21h. at the beginning and end of the month respectively, and can be seen throughout the morning hours. It crosses the meridian at 4h. 16m. on January 15. At the beginning of the month the planet is 476 million miles from the earth, and at the end of the month 437 million miles. Saturn, in the constellation of Gemini, sets at 6h. 52m. at the middle of the month. Its distance from the earth increases from 748 million miles to 764 million miles between January 1 and 31.

Times of rising and setting of the sun and moon are given below, the latitude of Greenwich being assumed:

| Jan. | Sunrise | Sunset |
|---|---|---|
| 1 | 8h. 06m. | 16h. 00m. |
| 15 | 8h. 00m. | 16h. 20m. |
| 31 | 7h. 41m. | 16h. 47m. |
| **Jan.** | **Moonrise** | **Moonset** |
| 1 | 18h. 03m. | 9h. 31m. |
| 15 | 9h. 02m. | 17h. 54m. |
| 31 | 20h. 17m. | 9h. 24m. |

There will be an annular eclipse of the sun on January 14, invisible in this country but visible in parts of the southern hemisphere. The earth makes its closest approach to the sun on January 1 when its distance is 91,455,000 miles.

An interesting phenomenon which often puzzles some people, occurs during the early part of January and the late part of December. The mornings decrease in length while the afternoons and the whole periods from sunrise to sunset increase. Its explanation is as follows. Owing to the eccentricity of the earth's orbit the sun's motion in the ecliptic is not uniform, being greatest when the sun is at perigee, that is, nearest the earth, which occurs about January 1. Imagine a point which coincides with the true sun at perigee and which moves round the ecliptic in a year, *but at a uniform rate*. The name "dynamical mean sun" is given to this imaginary point, and obviously irregularities due to the sun's varying motion in longitude are eliminated by this hypothetical sun. Another problem is presented by the obliquity of the ecliptic, and to overcome this the "astronomical mean sun" is defined to be a point which moves on the equator in such a manner that its *right ascension* is always the same as the longitude of the dynamical mean sun.

Generally the term "mean sun" is used for the "mean astronomical sun", and *mean noon* is the time of transit of this mean sun, not of the *true* or *apparent sun*. At any instant the mean solar time is measured by the mean sun's hour angle, and the apparent solar time is measured by the hour angle of the apparent (true) sun. The *Equation of Time* is defined as the amount which must be added to the mean time to obtain the apparent time, and as mean time is kept by a clock and apparent time by the sun, the following relation is obvious:

Sun time − clock time = equation of time.

The equation of time vanishes four times a year—on April 16, June 14, September 1, and December 25 respectively—and its maximum value is, 16m 22s. on November 3. (These dates may vary a little according to the year, but they can be accepted as approximately correct.)

Now let us examine the effect of the equation of time during the end of December and beginning of January. At all times of the year the interval from sunrise to *apparent noon* is the same as the interval from *apparent noon* to sunset, if we ignore very small effects due to the sun's changing declination. But when we speak of morning and afternoon we do not refer to the apparent sun but to the *mean sun*, and hence our morning is the interval between sunrise and *mean noon* and our afternoon is the interval between *mean noon* and sunset. To illustrate the point look at the times of sunrise and sunset as given in the *Nautical Almanac* for 1945, taking the latitude as 52° and the date as February 16. The times of rising and setting of the sun are given as 7h. 14m. and 17h. 15m. (see pp. 468-9), and we shall call the latter 5h. 15m., deducting 12h. from the time as given. The length of the morning is 12h. − 7h. 14m. = 4h. 46m., and the length of the afternoon is 5h. 15m.; deducting the latter from the former we obtain −29m. On p. 8 of the *Nautical Almanac* the equation of time February 16 is given as −14m. 13.96s., which is practically half the above difference. This relationship always holds, as the reader can verify from other examples for various dates. It must be remembered that the hours of rising and setting of the sun are given only to the nearest minute, and hence slight discrepancies in the relation referred to may be expected. If $r$ is the mean time of sunrise and $s$ the mean time of sunset diminished by 12h., $E$ being the value of the equation of time, the relationship can be expressed thus:

$$(12 - r) - s = 2E.$$

Referring again to the *Nautical Almanac* it will be found that at the solstices—summer or winter—the length of the day is altering very little and for the present purpose we shall consider it to be a constant. At the solstices the equation of time is decreasing; thus for 1944 it changes from 0m. 33.42s. on December 24 to −0m.26. 15s. on December 26 and, regarding the length of the day as a constant, $c$, we have the following equation, noticing that $12 - r$ is the length of the morning:

$$12 - r + s = c$$

Combining the two equations it follows that

$$2s = c - 2E, \text{ or } s = \tfrac{1}{2}c - E$$

Since $E$ is decreasing $s$ must be increasing, which means that the afternoons are longer and the mean time of sunset is later.

Eliminating $s$ between this last equation and either of the others,

$$r = 12 - E - \tfrac{1}{2}c$$

Since $E$ is decreasing $r$ must be increasing, that is, the mean time of sunrise is later. Hence the afternoons begin to lengthen while the mornings continue to shorten. The same thing takes place about the time of the summer solstice, but for obvious reasons it is not so noticeable then. Early in January the length of the days increases and the constant $c$ can no longer be used; the phenomenon then ceases.

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THE Royal Institution has now announced the programme for the series of children's lectures which the Astronomer Royal is to deliver at Christmas. His theme is "Astronomy in our Daily Life." The first two lectures will deal with the spinning of the earth on its axis and its revolution around the sun. These will be followed by three talks entitled respectively "How we get our Time," "Finding the Longitude" and "Clocks and Time-keeping." In his final lecture, Sir Harold Spencer Jones will discuss the methods used for finding position at sea and in the air. The series, which will be illustrated by experiments, commences on December 28th. For children the subscription for the course is half-a-guinea; adults, one guinea.

# The Bookshelf

**The Oceans.** Their Physics, Chemistry and General Biology. By H. U. Sverdrup, M. W. Johnson, R. H. Fleming. (New York, Prentice-Hall; London, Allen & Unwin, 1942; pp. 1087; 63*s*.).

THIS book presents a general and clear picture of the various fields of oceanography. It includes an account of the movements of the waters which take place continuously within the oceans, of the forces which cause, and modify them, and of the deductive reasoning on which most of our present day knowledge rests. Progress made during the last thirty years in these studies is set out as a coherent whole for the first time in the English language in this book and its companion volume *Oceanography for Meteorologists*. Dr. Sverdrup—well-known as an arctic explorer and oceanographer—is to be congratulated on having met a very real demand and in having produced a clear readable account of the complex interplay of forces which control the physical state of the oceans—the changes with increasing depth of the temperature, salt content and oxygenation of the water, of how and why these vary from place to place and of how they are modified by, or themselves set up, the ocean currents. Well illustrated and documented, these chapters form a first-rate introduction to the fascinating subject of physical oceanography, a branch of science still in its infancy though born in the days of the early navigators, and now attaining an extended interest as it links with progress in meteorology.

Other chapters are devoted to the composition of sea water—a solution of many different salts in remarkably constant proportion one to the other. This forms no mere tale of analytical procedure; constituents are used by plants and animals. On the lack or abundance, notably of available phosphorus and nitrogen salts, in the right place at the right time, the varying fertility of the waters depend, much as in our fields and pastures. However, there is the difference that on land life is concentrated on or near the surface, whereas in the oceans animals live to a depth of two or three miles, although growing plants are limited to an upper, often shallow, layer where there is sufficient light.

The relation between marine plants and varying concentration of nutrient salts in the sea, the penetration of light and removal of the upper layers from below have proved fruitful sources of investigation. Upon such relations largely depend the differing fertility between one area of the sea and another. The chapters devoted to the relation of plants and animals to their environment, both chemical and physical, summarise research in this field, and contain references to the literature which is dispersed in many journals. The most recent contributions, which have been many, seem to be rather stressed—perhaps without detriment to the whole because the original contributions to this subject, particularly by American investigators, are all singularly well documented.

Chapters are devoted to marine plants and animals, and their interrelations, providing in small space a useful outline to this vast subject, there being many million marine species. A final chapter is devoted to sedimentation and the nature of the sediments on the floor of the ocean.

Most of our knowledge concerning the drift and mixing of the water masses in the oceans and mixing of the waters rests on inference—direct observations, except of surface currents, have been few, owing to difficulties of working at great depths—and much of this inference relies on hydro-dynamic calculations and the use of Bjerknes theorem. In addition to a lucid explanation, this book contains useful tables for making these computations. A number of charts are included showing the distribution of salinity, temperature, depth, currents, etc., in the great oceans. It is to be hoped, and it may be confidently expected, that this is the first of many editions of an excellent and valuable book. H.W.H.

**Gravity Die casting Technique**. By George W. Lowe; pp. 96; with 61 illustrations (including 5 plates). (Hutchinson, 9*s*. 6*d*.).

THIS little book, which is divided into 10 chapters, describes gravity die-casting from the point of view of mould design. A very poor beginning to the book is made in the introductory chapter, in which the question of the relative costs of sand-casting, pressure and gravity die-casting is very briefly considered. This chapter could be greatly improved and would have been better dealt with more fully at the end of the book. In the second chapter, which is intended to be historical, reference is made to die materials, but no real attempt has been made to inform the reader of the merits of various alloys. Chapter III is entitled "Pressure Die-casting and Slush Casting" and seems quite out of place. Some looseness of expression is all too frequently found in this and the previous chapters. For example, on p. 20, the following awkward and unscientific sentence occurs—"A fold is formed when the liquid metal parts within the casting form, one part solidifying while the other remains molten (temporarily)". There are many such examples of uneasy phraseology. An improvement is noted in the next two chapters which deal with gravity die-casting and die design in general terms, and contain several very useful notes.

Chapter VI deals with some of the details of die design, and the section on cores and core locations is good. Numerous examples are given of the application of loose pieces and many useful ideas are brought out. The next three chapters, dealing with die-mould design, show a further distinct improvement. Well illustrated examples of die-mould design are given, including so-called "semi-permanent" die-moulds employing sand cores. Some confusion may occur, however, with the use of the term "semi-permanent" as this is understood by many to refer to the use of cements, as in the "Randupson" process. The use of collapsible metal cores is described in the last of these three chapters. The final chapter deals with various miscellaneous aspects of die-mould making, such as die fastenings, ejecting of the final casting, lubrication, venting and pre-heating of the die-mould. More space could easily have been given, however, to mould coatings, which have quite an important bearing upon surface quality. The ending of this chapter is rather weak.

To sum up, the one outstanding and particularly commendable feature of the book is its abundance of clear, explanatory line-drawings. The price, however, cannot be regarded as on the modest side, particularly when comparison is made with other recent books on casting and founding. It does its best, however, to fill a long-empty gap on the die-casting shelf, and on this account is a welcome addition. It is hoped, nevertheless, that further and improved editions will be forthcoming, when a little more attention should be given to purely metallurgical considerations. The addition if an index would also add to its value. One final word should be addressed to the publishers—please insert the date of publication! E.V.M.

**The Story of Tools**. By V. Gordon Childe; (pp. 28 + 16 pp. of illustrations; 1*s*. 6*d*.). **Science and Progress**. By S. Lilley. (Cobbett Publishing Co., 1944; pp. 68, illustrated; 2*s*. 6*d*.).

THE authors of these two companion volumes have avoided the easily committed sin of condecension, probably because they aimed at and hit a particular target—"young people in industry or at school." Professor Gordon Childe has produced a remarkable piece of condensed writing—I have read plenty of books which take twice as many words to relate half as many facts—and his 62 illustrations are alone worth the price. Dr. Lilley, picking himself a big subject, has done well to compress so reasonable an account of so controversial a subject into 68 pages. He shows how science, its development to a large extent conditioned by social needs, has brought many benefits. He considers what science does under different social and economic systems, and indicates the obstacles to the full utilisation of science which those systems create. Disdaining to "sit on the fence", Dr. Lilley states his conclusion that science prospers best under socialism. His arguments, one feels, will carry greater conviction since there is nothing one-sided about them. A few mistakes have crept in—for instance his remark "Around 1900 red was about the only easily made fadeless dye" would be hard to substantiate—but these are minor blemishes. W.E.D.

# Far and Near

### Explosives and the Monroe Effect

THE work of scientists on the investigation of the principle of the hollow charge has placed modern warfare on a new basis, and has made possible the designing of a number of new and devastating weapons.

The effects of the detonation of a charge of explosive are well known. It is sometimes said that a bomb or other explosive has "struck downwards" or in some other direction, but this is a popular delusion. An aircraft bomb for instance distributes its blast evenly in all directions.

It may, in falling through them, partially wreck some structures before it detonates. It may penetrate the ground before it goes off, in which case the blast will be directed upwards to some extent by the walls of the crater. The same thing applies to a shell from a gun.

The flying bomb had very shallow penetration, so that the blast from it appeared to travel horizontally in all directions. On the whole the blast from all types of shattering missiles travels in all directions, and by this means achieves the object of causing general destruction. For the special purpose, of achieving directional explosive effect in special circumstances, the principle of the "hollow charge" has been brought into use in many applications. The effect of an explosive charge can be concentrated or focussed by hollowing out the surface of the charge on the side against the object to be attacked. This phenomenon was first clearly described by an American expert, Monroe, who showed that a hole could be blown clean through the three-inch steel wall of a safe by the use of a hollow charge of dynamite, whereas the explosion of a flat mass of dynamite laid on the surface of the safe produced no material effect. The principle is accordingly known as the Monroe effect; sometimes it is called the Neumann effect. The essential difference between the hollow explosive charge and charges to which the principle has not been applied is that whereas the normal charge exerts a general *shattering* effect, the hollow charge exerts a *piercing* effect and punches a hole of more or less even diameter even in the hardest steel and concrete.

The full elucidation of the principle in its application to military uses has occupied a number of chemists and physicists over a period of some years. The various explosives had to be classified according to their merits when used as hollow charges. The best shapes for the "hollow" had to be determined; it is a striking fact that the cavity must be of a regular geometrical shape, such as a cone, paraboloid or hemisphere. Many other points had to be investigated, such as the relationship between size of charge and depth of penetration for various materials, and of the distance from the target at which the charge gives the best piercing effect.

The hollow charge principle has been introduced into weapons for many purposes. These weapons fall into two types—demolition charges, and missiles or projectiles. The object achieved with each type is very much deeper penetration of the target, with an accompanying diminution of the quantity of the explosive necessary. The effect has been fully exploited in special demolition charges. These range from small cylindrical charges weighing 10 lbs.—known colloquially as "beehives"—which are able to penetrate nearly a foot of solid steel or two feet of concrete, to heavy assault charges designed to penetrate the thickest pillbox wall.

"Beehive" type charges have many applications. They may be used to produce rapidly a borehole in masonry, concrete or brickwork; for example, in bridge demolitions boreholes would be made in piers or abutments, and afterwards filled with explosive, which on detonation causes disruption of the structure. They may be used to make holes in rocky ground for anchors or telegraph poles, or again as a speedy method of scooping out shallow trenches. A serious problem in bridge demolition is the heavily reinforced steel and concrete bridge common on main roads in most countries. This type of bridge is so strong that a great deal of time and explosive are necessary to effect a complete demolition. A shaped charge, known as the "hayrick", has been produced in order to deal with these bridges in a rapid and effective manner. The "hayrick" is a charge which cuts along a line, as opposed to a "beehive" which makes a deep hole of small diameter. When fired beneath a reinforced concrete beam or slab, it cuts through concrete and steel and so reduces the structural strength that the bridge span collapses.

Other types of shaped charge include special anti-concrete charges which are used in conjunction with other special devices for breaching anti-tank walls. There is also a small version of the "Hayrick" known as the "Stook". Although the "Stook" weighs only a few ounces, it is capable of cutting through steel an inch thick, and was used effectively for clearing from the Normandy beaches the mass of steel obstacles which presented a barrier to the landing of our tank landing craft. Among projectiles (as opposed to "laid" or "demolition" charges) using the hollow charge principle may be mentioned the P.I.A.T. Much research has been put into the perfection of this weapon. The earlier type of projectile had a direct action fuse, which detonated the filling only on impact with a hard surface. The more recent issues have been fitted with a fuse which explodes the bomb even on soft earth if it misses the target, so that our advancing troops are not harassed by unexploded and therefore possibly dangerous missiles. Apart from the P.I.A.T. there exist several other types of projectiles for use particularly against tanks and a grenade, both with powerful effect.

### British Scientists Renew Contact with French

CONTACT between French and British scientists is beginning to be re-established. The Physical Society for instance has sent a message of greetings to its opposite number in France, the British Association has exchanged messages of goodwill with the French Association for the Advancement of Science, and the Association des Travailleurs Scientifiques (formed a few days after the liberation of France from scientists who were members of the Resistance Movement) has been in communication with the Association of Scientific Workers.

At the meeting of the Physical Society held in London on November 9, the president, Professor E. N. da C. Andrade, read out the names of a number of French physicists who had been killed during the war. G. Dechêne, J. Farineau, H. du Mesnil du Buisson and J. Rossignol fell on the field of battle. F. Holweck, famous for his work on soft X-rays and other notable researches, was murdered by the Gestapo, and J. Solomon, one of the most promising of the younger theoretical physicists, was shot by the German military authorities. "Deaths that we have to deplore, some no doubt accelerated by the traditional brutalities of the Germans, are those of H. Buisson, H. Chipart, A. Dufour, A. Guillet, Victor Henri, J. Lemoine, Jean Perrin, Émile Picard and Pierre Weiss. Besides those who are known definitely to have lost their lives, there are others whose ultimate fate is unknown. H. Abraham, Eugene Bloch, G. Bruhat, L. Cartan, C. Sadron and J. Yvon have been deported to Germany, and we dare scarcely hope that they have received humane treatment there," added Professor Andrade. He also stated that a new publication, *Cahiers de Physique*, had appeared during the occupation, and that the first number of another new journal, *Annales de Geophysique*, was now in the press.

### Laboratory Assistants for Schools

THE importance of the laboratory assistant in research laboratories is discussed elsewhere in this issue. No less worthy of attention is the status and supply of laboratory assistants for schools, and an interesting article on this question was printed recently in *The Observer*. The writer pointed out that hitherto only the universities and some rich commercial firms have had an adequate number of these workers; in poorer colleges and schools where science is taught, they are not to be found. When demobilisation is begun priority will be given to the release of teachers. That will be simple for the arts teacher who, given his books, his classroom and his blackboard, can get on with his job. Not so the teacher of science. Will he have to waste the precious time of the laboratory periods making preparations and collecting things?

The article suggested that there are many laboratory assistants in the Forces

who should have equal priority with the teachers. Furthermore, there are many men and women in the Forces who already have part of the training needed. "How many men and women have been trained in radio work in connection with radio-location and other radio services of all three Forces? Many of these people would be most suitable for work in physics and engineering labs. Many others have been trained for work in Service medical laboratories, malaria, and blood transfusion units. They are already equipped for hospital work; with a little training they could adapt themselves for posts in biological laboratories."

Schools and technical colleges, most of which are run by local authorities, should realise that the employment of laboratory assistants would greatly improve the quality of the teaching. The jobs should be properly paid to attract the right people and give them pride in their work, concluded the writer.

**Lamarck's Bicentenary**

THE bicentenary of the birth of Jean Baptiste Antoine Pierre Monnet de Lamarck, the great French biologist, was celebrated by the Linnean Society on November 23. Mr. R. Winckworth read a paper entitled "From Linnaeus to Lamarck", Professor F. Wood-Jones spoke on "Time and Lamarck", and Professor J. B. S. Haldane opened a discussion upon the importance of Lamarck's work. Lamarck's certificate for election to membership of the Linnean Society (dated 1820) was exhibited at the meeting.

Lamarck was born on August 1, 1744, and died in 1829. After a brief career in the Army—he was made an officer after serving in the ranks for only one day, being promoted on the field of battle after all the officers of his company had been killed—he worked for a time in a Paris bank. Botany became his hobby, and within a short time he produced the first real flora of France, *Flore Française*, which was published in 1778. Here he was responsible for introducing that important innovation, the dichotomous key. In 1788 he became custodian of the Jardin du Roi and when, five years later, that institution was reconstructed to form the Museum of Natural History he was appointed the first professor of zoology there. Classification attracted him and he was responsible for putting the taxonomy of Invertebrates into a reasonable sort of order. His book *Histoire des Animaux sans Vertebres* ran to seven volumes and took many years to complete. In his *Philosophie Zoologique* he put forward a theory of evolution which has come to be known as Lamarckism. He advanced the idea that modifications arise in animals during their lifetime as a result of stimuli which they receive from their surroundings. (He was however, careful to note that the environment can effect no *direct* changes whatever upon the organisation of animals). He also argued that through disuse certain organs in the animal's body may dwindle. These modifications, according to Lamarck, are inherited to a certain extent by succeeding generations, and the accumulated modifications in time result in a new kind of animal evolving. The crux of the matter, as J. Arthur Thomson has said, is whether acquired characters can be inherited. The majority of biologists consider there is no evidence that they are and regard Lamarck's theory as still unproved, in spite of a few workers who have made claims to the contrary.

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*The Indian scientific mission, which arrived in Britain in October, departed at the beginning of this month. Before returning to India they are visiting America. This photograph was taken at a reception given to the mission by the Royal Society. From left to right: Professor J. N. Mukherjee, Dr. Nazir Ahmad, Sir J. Chandra Ghosh, Sir Henry Dale (president of the Royal Society), Sir Shanti Bhatnagar, and Professor S. K. Mitra.*

**Personal Notes**

THE death occurred on November 22 of SIR ARTHUR EDDINGTON, O.M., F.R.S., Plumian Professor of Astronomy at Cambridge since 1913. He was aged 61. Educated at Owens College, Manchester, and at Cambridge University, he gained the Smith's Prize in 1907 and in that year was elected a fellow of Trinity College. From 1906 to 1913 he was Chief Assistant at the Royal Observatory, Greenwich, after which he began the thirty-one years of his professorship which lasted throughout a period that may truly be called the Golden Age of Astrophysics. He was not the only great figure who took part in the advances made in this field of knowledge. In Britain men such as Professor E. A. Milne, the late Sir R. H. Fowler, Sir J. H. Jeans and Professor S. Chapman all made striking theoretical contributions, and among the most important workers outside Britain were H. N. Russell, G. E. Hale, Rosseland, Oort, Unsöld and Strömgren. But few would dispute Eddington's right to be called the foremost theoretical astrophysicist of all that golden epoch.

It was he who analysed and discussed the phenomenon of "star streaming"—the observed fact that the motions of the stars show a preference for one particular direction in space. It was he who proposed the first really tractable theory of the formation of the spectrum lines in the atmospheres of stars. To him we owe the discussion of the internal economy of stars. From his pen came the papers which showed that on theoretical grounds there must be a relation between their brightness and their mass. His development of the theory of pulsating stars gave the first satisfactory account of the Cepheid variable stars. His discussion of the observed and the theoretically predicted brightnesses of stars and of certain discrepancies between them resulted in the conclusion that hydrogen must be the most abundant constituent of the stars, and led the way to the explanation of the mechanism by which stars generate their energy. An attack, along completely new lines, on the same problem in the case of the extremely dense white dwarf stars gave more recently some very important results which may provide an explanation of their origin and of their place in the evolution of the stars. His discussion of the behaviour of hydrogen in the outer layers of the sun has led to the important result that a marked circulatory motion of the gases must exist. Eddington's work was not, however, confined to astrophysics. He was one of the first men in this country to appreciate the value of the Theory of Relativity. Not only did he expound it in his *Report on The Relativity Theory* published in 1918, but he also made, at the total eclipse of 1919, the test of the bending of rays of

light in the sun's gravitational field which had been predicted by Einstein. His own book on the mathematical theory of relativity is the best text-book of the subject in English and has a value second only to his treatise on the internal constitution of the stars which, although published as long ago as 1926, is still indispensable to the student of astrophysics.

In the last fifteen years Eddington had turned part of his attention to the problem of the unification of the theory of relativity with the quantum theory and in 1936 he set out his conclusions in his *Relativity Theory of Protons and Electrons*. This has been the subject of considerable controversy. Still more controversial has been the reception of the philosophical views which he had formed as the result of this work, and which he expressed in such brilliantly written popular books as *The Nature of the Physical World, Science and the Unseen World, New Pathways in Science*, and *The Philosophy of Physical Science*. Time alone will show whether he was correct in his development of this theory, but, even if he were not, his other researches have earned him the admiration and respect of all who knew his work, and have set the seal of permanence on his fame.

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SIR JOSEPH A. ARKWRIGHT, F.R.S., the eminent bacteriologist, died on November 22 at the age of 80. Among his researches may be mentioned the work he did on the transmission of typhus by the louse. While investigating this problem in Cairo his collaborator, Bacot, died of the disease, and Arkwright contracted it though he recovered after being dangerously ill. For many years he was attached to the Lister Institute, and he was joint author with Sir John Ledingham (whose death we recorded two months ago) of *The Carrier Problem in Infectious Diseases* (1912). He was elected F.R.S. in 1926, and knighted in 1937.

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MISS MARY EDITH DURHAM, who died in London on November 15 at the age of 80, was well-known as an anthropologist and traveller, being considered the foremost authority in Western Europe on the manners, customs and political aspirations of the more primitive peoples of the Balkans. Her earlier years were devoted to painting in which she achieved considerable distinction. Among the book illustrations which she did were those to the volume *Reptilia* in the Cambridge Natural History. In her early thirties she began to travel in the remoter regions of the Balkans, more especially in Siberia and Albania, where for many years she spent the greater part of her time. She wrote a number of books about her travels and observations, summing up her knowledge of the Balkan peoples and their racial history in the volume *Some Tribal Origins, Laws and Customs of the Balkans*. For a long time Miss Durham served on the council of the Royal Anthropological Institute.

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THE death occurred on November 28 of SIR JOHN JACOB FOX, who succeeded Sir Robert Robertson as Government Chemist in 1936. Born in 1874, he was educated at the Royal College of Science and Queen Mary College and joined the Government Laboratory in 1904. He was a past president of the Royal Institute of chemistry.

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**Nobel Prizes: Physics and Chemistry**

THE Nobel Prizes for Physics for 1943 and 1944 have gone respectively to PROFESSOR OTTO STERN (research professor in the Department of Physics at the Carnegie Institute of Technology, Pittsburgh) and PROFESSOR I. I. RABI (professor of physics in Columbia University, New York). The Nobel Prize for Chemistry for 1943 has been awarded to PROFESSOR G. C. VON HEVESY, of the University Institute for Theoretical Physics, Copenhagen. No chemistry award has been made for 1944.

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**Royal Society's Medals**

THE Royal Society has awarded the following medals for 1944: Copley Medal, SIR GEOFFREY TAYLOR; Rumford Medal, DR. H. R. RICARDO; Davy Medal, SIR ROBERT ROBERTSON; Darwin Medal, DR. I. STANLEY GARDINER; Hughes Medal, PROFESSOR G. I. FINCH.

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**Xmas Lectures for School Children**

THE Birmingham and Midlands section of the Royal Institute of Chemistry has arranged for two lectures to be given to senior elementary and secondary schoolchildren of Birmingham. The lecturer will be Dr. J. A. Newton Friend, and his subjects will be "Fire" and "Science in Antiquity". About 1,500 children are expected to attend.

**Conference on Industrial Science**

"THE Place of Science in Industry" will be discussed at a London conference the British Association is holding at the Royal Institution on January 12 and 13. Further particulars can be obtained from the B.A. Secretary, Burlington House, Piccadilly, W.1.

**"666"**

A NEW weapon in the war against locusts is being introduced in the Middle East and East Africa. This is a synthetic insecticide still on the secret list and provisionally called "666". It is considered possible that it may replace sodium arsenite in the poison bait used for killing locusts. It has already proved satisfactory in trials carried out in East African colonial territories, where locusts constitute an almost constant menace to crops, and has the advantage of not being dangerous to domestic animals. "666" is being made in quantity in Britain.

**Bombing through Cloud**

THROUGH an error on the part of American censorship a sketchy story of the "magic eye", which has enabled Allied airmen to bomb targets through dense cloud, was released last month and published in the national press of November 28. The invention, it was stated is in use in all Allied bombers and fighters. (The use of radar by warships was disclosed many months ago).

The following account was given to the Press by an R.A.F. spokesman. The "gen box", as the R.A.F. nick-named the device, can best be likened to television. When the pilot switches on the set radio waves are transmitted from the plane and, after reflection by objects on the ground, these produce an image on a screen in the plane. The picture is not as clear as a television picture, but the outlines of the target stand out clearly enough to make accurate bombing possible.

**Gramicidin S**

IN addition to penicillin some twenty other anti-bacterial substances have been obtained from bacteria and moulds. Scientists of the Institute of Tropical Medecine in Moscow, following up the work of Dubos on tyrothricin and gramicidin (two anti-biotic substances produced by *Bacillus brevis*) have isolated yet another anti-biotic which they call *Gramicidin S* (Soviet Gramicidin). The organism which generates it is a strain of *Bacillus brevis* that thrives at high temperatures, giving the maximum yield of gramicidin S at about 40° C. It is claimed to be effective against several gram-negative bacteria (whereas tyrothricin is ineffective against *all* gram-negative bacteria) and it is said to prevent the growth of *Bacillus proteus*, *Bacillus coli* and the germs causing cholera, dysentery and paratyphoid, all of which are listed as insensitive to penicillin. Gramicidin S appears to have great stability, losing none of its antibacterial activity when, in the dry crystalline form, it is heated to 160° C. Reports of its clinical trials published in *Nature* (1944, **154**, p. 703) and *The Lancet* (1944, 247, p. 717) show how the suppuration of burns and gun-shot wounds can be prevented by its use. A monograph on gramicidin in Russian is available.

**Bomb-Sensitive Plant**

AT least one plant that is sensitive to contact, to the extent that its leaves collapse when the plant is touched, is sensitive to the distant explosion of bombs. This fact is recorded by E. S. Grew, writing in the *Illustrated London News* for October 28. The plant is *Desmodium gyrans*, otherwise known as the "Telegraph Plant".

**Scientific Attachés**

THE Parliamentary and Scientific Committee is considering the preparation of a memorandum dealing with the desirability of appointing scientists as attachés to the principal British embassies overseas. The secretary has already received communications on this topic from Professor A. V. Hill, Professor Scott-Watson, Sir Henry Tizard, Sir Peter Bennett, M.P., and Sir Lawrence Bragg. Mr. J. G. Crowther, director of the British Council's science department, is also giving his informal advice.

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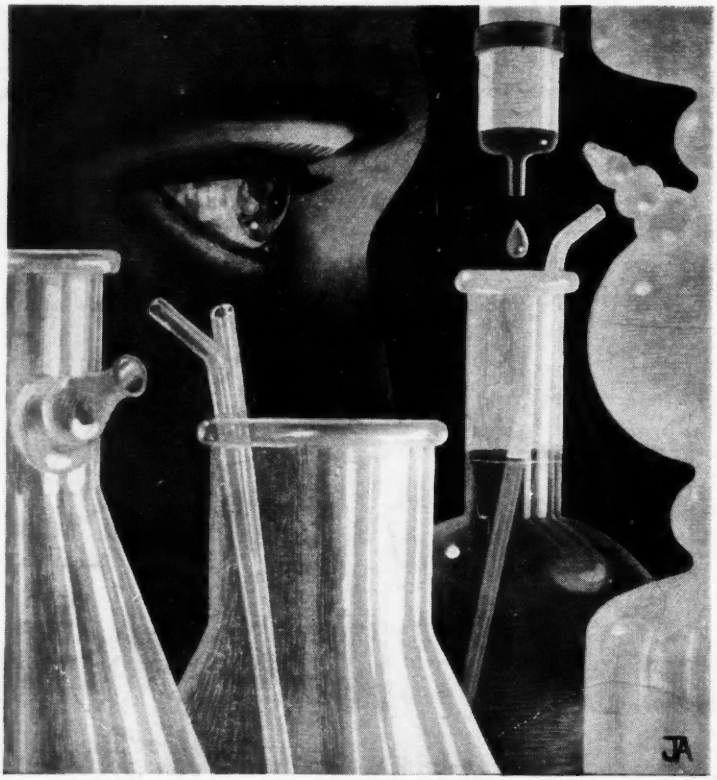
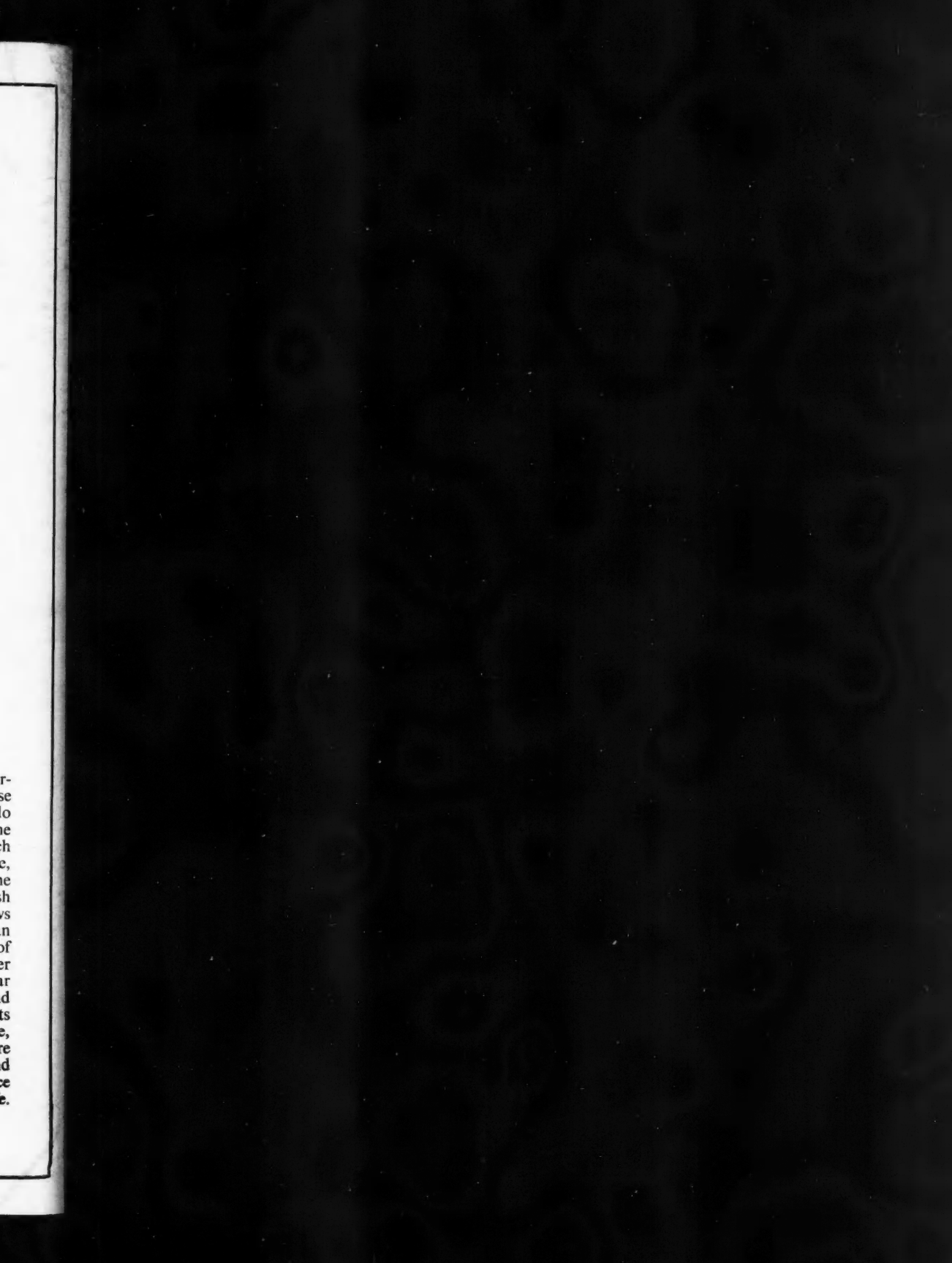



## AT YOUR SERVICE

*IMPROVEMENTS* in our daily life follow one another so swiftly that we tend to accept them as a matter of course. We note advances in the colour, finish and texture of our dress materials or the fabrics which go to furnish our houses. We even use without surprise entirely new types of textiles and other materials. We read with only a passing wonder of the strides being made in the prevention and cure of disease among men and animals, and for our protection, in the detection of crime. We have ceased to be astonished at the developments which make our daily round and common task, in kitchen, work-room and garden, simpler or more enjoyable. We accept without comment the progressive advance in quality of such entertainments as the cinema and radio. Even in a world at war we seldom pause to inquire how it is that we are still able to enjoy efficient substitutes for the articles which are temporarily no longer obtainable. Or how it comes about that the evils of under-nourishment and the scourge of epidemic disease have been kept so firmly in control. We shall do better to remind ourselves occasionally that none of these things come of their own accord. In each one of them we shall, if we trouble to inquire, find the hand of the research chemist and of the chemical industry — and not least of the British chemical industry. The record of history shows that British chemists have always been in the van of invention and discovery. It is not the least of Britain's justifications for the regard of other nations that, even stretched on the rack of war though she is, her sons and daughters, fleets and armies scattered all over the globe, her chemists have stood to their task. Today, as in peacetime, British laboratories and chemical factories are working with undiminished resource and energy to see that the benefits of science are increasingly applied in our daily life.

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